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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0050

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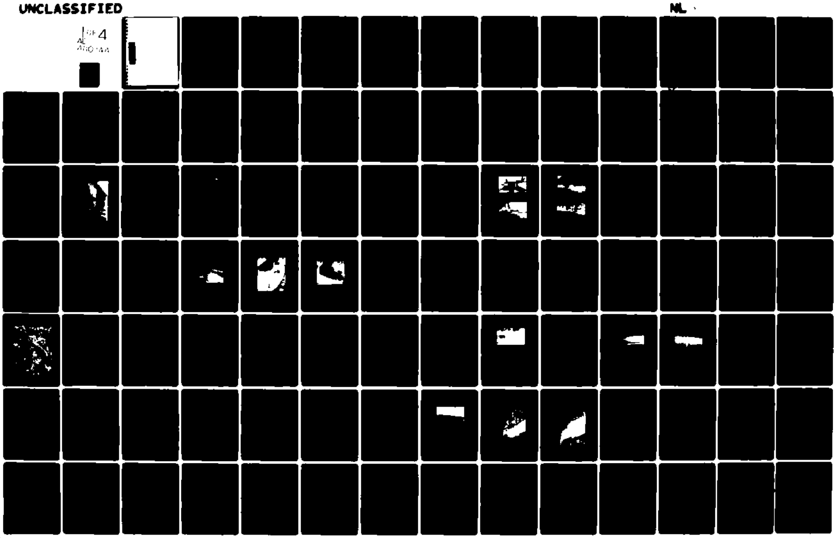

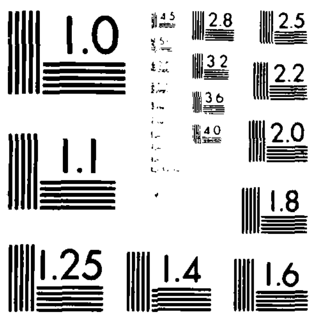

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The overall objectives of this report are to assess the impacts, both positive and negative, of the Corps of Engineers' activities on Pool 1 of the Upper Mississippi River. An analysis of natural and socioeconomic systems is included. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and water quality. Socioeconomic systems include industrial and recreational activities, and cultural considerations.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

POOL 1

of the Northern Section of the UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
Under Contract No. DACW37-73-C-0059

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November 1973

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

FOREWORD

Purpose of the Environmental Studies

The National Environmental Policy Act of 1969 directs that all agencies of the Federal Government "include in every report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement . . . on the environmental impact of the proposed action." The Act deals only with proposed actions. However, in keeping with the spirit of the Act, the U. S. Army Corps of Engineers has developed its own policy that requires such reports on projects it has completed and for which continuing operational and maintenance support are required.

In keeping with its policy, on January 15, 1973, the St. Paul District of the U. S. Army Corps of Engineers contracted with the North Star Research and Development Institute to prepare a report assessing the environmental impact of the Corps of Engineers' operations and maintenance activities on the Mississippi River from the head of navigation in Minneapolis, Minnesota to Guttenberg, Iowa. Included also are the Minnesota and St. Croix Rivers from their respective heads of navigation at Shakopee and Stillwater, Minnesota to the Mississippi River. This portion of the Mississippi River basin will subsequently be termed the "Northern Section" of the upper Mississippi River, or the "study area", or the St. Paul District.

The Corps of Engineers has been active in the Northern Section since the 1820's, when they first removed brush and snags from the river to permit navigation as far north as Fort Snelling. Later in the 1870's, further improvements were made, primarily through construction of wing dams, to deepen and maintain the channel. Presently, the river in the study area consists of a series of pools, which were created by the construction of navigation locks and dams in the 1930's. Several recreation areas along the river were also built by the Corps.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the Corps' activities on the Northern Section. In addition, the study is to provide a broad background of information for periodic reassessment and more detailed analysis of impacts. The activities are defined as operations and maintenance activities and mainly include operations of facilities (locks and dams) and maintenance of the navigation channel (dredging). Although the environmental impacts of earlier operations are also being sought, most of the information will concern the impacts of the present nine-foot navigation system.

The studies are designed not only to identify the impacts, but to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effects of creation of the pools on recreational activities and wildlife habitat, effects of dredge spoil disposal on the natural ecosystem and on recreation, and many others. As a result of identification and assessment of the impacts, it will be possible to suggest ways of operating the facilities and maintaining the navigation and recreation system to amplify the positive and minimize the negative results of the Corps'activities. The study will provide a comprehensive basis for the St. Paul District to prepare an environmental impact statement consistent with the National Environmental Policy Act of 1969 and the policy of the U. S. Army Corps of Engineers.

Scope of Current Report

The present report covers the entire study program only from January, 1972 through November, 1973. The report contains both historical information and data collected in the field from activities such as water quality investigations and sampling of riverbank vegetation.

Research Approach

Three aspects of the research approach used in the study are: (1) the benchmark point in time, (2) data collection and analysis on the natural

systems, and (3) data collection and analysis on the socioeconomic activities.

Benchmark Time Period

In order to analyze the impact of the activities of the Corps of Engineers on the Northern Section of the Upper Mississippi River, it is necessary to select point in time which can serve as a benchmark. This benchmark is the year activities related to the nine-foot channel were initiated. Because the nine-foot channel project constructed in Pool 1 began in 1930, this year is taken as the benchmark. The pre-project condition of the river at and upstream from Lock and Dam 1 is taken as prior to 1930. Wing dams were built and Corps' activities on other channel projects took place prior to 1930. The pre-project information was obtained from available reports and from a variety of other sources cited at the end of each section.

Analysis of the Natural Systems

The impacts of Corps' activity on the natural environment for a given pool were determined by the individual investigator responsible for that particular pool. The Northern Section of the upper Mississippi River was subdivided into fourteen distinct segments for purposes of study of the natural environment: Pools 1 through 10, Pool 5A (lying between Pools 5 and 6), the Upper and Lower St. Anthony Falls (SAF) Pools (a single report covers both pools), the Minnesota River and the St. Croix River. A segment was assigned to an investigator on the natural sciences team as listed below:

Number of River Pools Involved	Total Length in River Miles	Pools	Principal Investigator	Organization
5	92.4	Upper and Lower Pools, Pool 1, Pool 2, Minnesota River, and St. Croix River.	Roscoe Colingsworth	North Star Research Institute Minneapolis, MN
1	18.3	Pool 3	Edward Miller	St. Mary's College, Winona, MN

4	82.6	Pools 4, 5, 5A and 6.	Calvin Fremling	Winona State College, Winona MN
2	35.1	Pools 7 & 8	Thomas Claflin	Univ. of Wisc., at LaCrosse, La Crosse, WI
1	31.3	Pool 9	James Eckblad	Luther College Decorah, IA
1	32.8	Pool 10	Edward Cawley	Loras College Dubuque, IA

Because different problems arise in different segments of the river, each investigating team used its own judgment in conducting its studies. However, North Star -- in conjunction with the investigators cited above -- developed general guidelines for conducting the field studies, acquiring data, and presenting the data in a final report. This required that North Star develop a reporting format that could be used for all pool reports so that the series of reports would have maximum utility and comparability.

Analysis of Socioeconomic Activities

The socioeconomic analysis for all pools in the study area was conducted by a team including Dr. C. W. Rudelius of the University of Minnesota and William L. K. Schwarz of North Star. The socioeconomic impacts were analyzed by the same team for all fourteen segments of the Northern Section because substantial economies in data collection were possible with this approach. The initial data for each pool were collected and then were submitted for review and updating to the investigator analyzing the natural systems for that pool. The suggestions of these investigators were incorporated in the socioeconomic portions of each pool report.

Report Objectives

Because the Corps is required to submit an environmental impact statement for each pool and tributary in the Northern Section on which they carry out

operation and maintenance activities, this study is being carried out and reported on by pool (and tributary).

The present report deals only with Pool 1 on the upper Mississippi River, described in detail in subsequent pages. Background information that applies to two or more pools in the study area appears as a portion of each appropriate report. This is necessary since the report on each pool must be capable of being read and understood by readers who are interested only in a single pool.

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to Pool 1. Specifically following this section, the report is in the format required for the Environmental Impact Statement, and seeks:

1. To identify the environmental, social, and economic impacts of the Corps' activities related to Pool 1.
2. To identify and, where possible, measure the beneficial contributions and detrimental aspects of these impacts and draw overall conclusions about the net effects of Corps' activities.
3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers and other public agencies and private groups to reduce detrimental aspects of the project.
4. To identify additional specific research needs to assess the impacts and increase the net benefits of Corps' operations.

The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and quality of the water. Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams and commercial fishing; recreational activities, such as fishing, boating, or hunting that are affected by Corps' operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

The present Corps of Engineers' project in Pool 1 (Mississippi River Mile 853.3 to 847.6, Figure 1) consists of the operation and maintenance of a dam and two locks and maintenance by dredging of a navigation channel of nine-foot minimum depth. The Corps' facilities include: (1) a fixed-crest dam, with provision for hydroelectric power production; (2) two navigation locks; (3) a control station, observation platform, guide walls and other structures; and (4) masonry to protect the bluff. The operation of these facilities provides for the passage of commercial and pleasure craft. Maintenance includes dredging the channel to assure the minimum depth, clearing of debris, and repairing the locks and dam.

AUTHORIZATION

The present nine-foot project was authorized by Congress by the Rivers and Harbors Act of July 30, 1930, as amended by Public Resolution No. 10, February 24, 1932, and by the Act of August 26, 1937 (See Table 1). Lock and Dam 1, completed in 1917 as part of the six-foot project, was modified to accommodate nine-foot-draft traffic in 1930. A second lock was added in 1932 on the landward side of the original lock. Additional acts have provided for locks and dam operation and care, harbor enlargement and channel dredging, and park and recreational facilities.

HISTORY

In 1824, a year after the sternwheeler "Virginia" initiated navigation to Fort Snelling, Congress authorized the Corps of Engineers to improve navigation of the Mississippi River by removing snags, wrecks, shoals and sandbars.

The first comprehensive improvement of the river for navigation was authorized by the Rivers and Harbors Act of June 18, 1878 (See Table 2) to obtain a 4.5-foot channel from the mouth of the Missouri to St. Paul. The Act of 1894 extended this project from St. Paul to Minneapolis by means of two dams at Mile

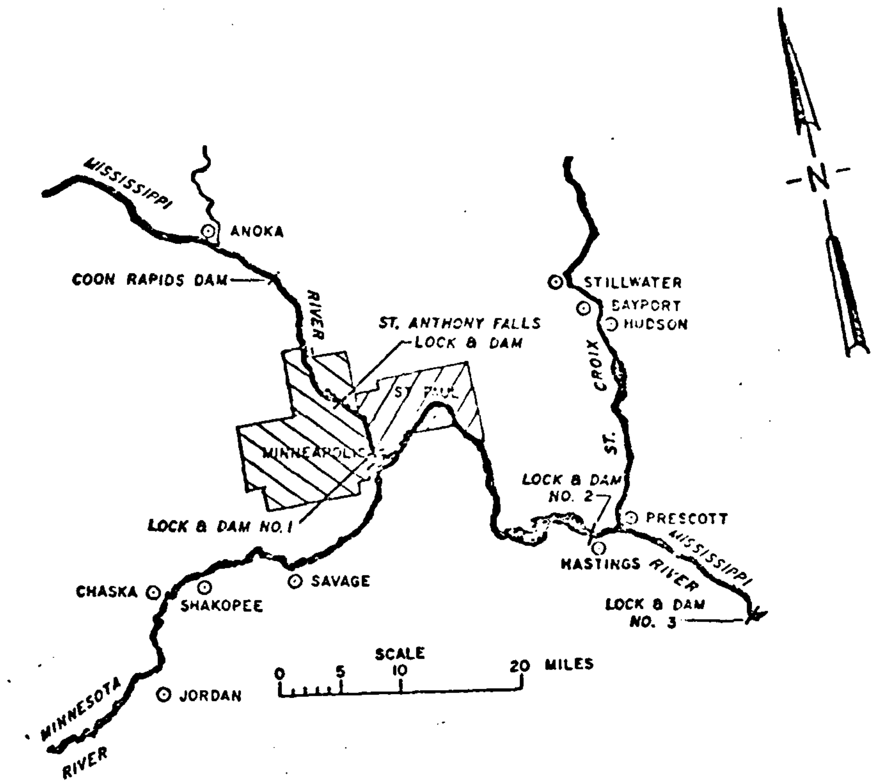

Figure 1. The Mississippi River and its Major Tributaries in the Twin Cities Area (FWPCA, 1966)

Table 1. Congressional Authorizations Pertaining to the 9-foot Channel (OCE, 1970).

Rivers and Harbors Acts	Work Authorized	Documents
January 21, 1927	Survey of Mississippi River from Missouri River to Minneapolis to determine feasibility of 9-ft. Channel	House Document, 69th Congress, 1st Session
July 3, 1930, amended by Public Resolution 10, February 24, 1932	Modify permanent structures under construction to accommodate 9-ft. Channel; complete survey for 9-ft. Channel. Chief of Engineers granted discretionary authority to modify plans as deemed advisable, construction of a parallel lock at Lock and Dam No. 1 dredging at head of pool.	House Document 290, 71st Congress, 2nd Session
January 26, 1934	Operation of snagboats, operation and care of locks and dams.	None
August 26, 1937	Adopted 9-ft. project from Illinois River to Minneapolis dredging at head of pool.	House Document 137, 72nd Congress, 1st Session
December 22, 1944	Public park and recreational facilities.	None
March 2, 1945	Changes or additions to payments, remedial works, or land acquisitions authorized by Rivers and Harbor Act of August 26, 1937 (House Document 34, 75th Congress, 1st Session), as Chief of Engineers deems advisable.	None

Table 2. Congressional Authorization Pertaining to Navigation Projects in Pool 1 Prior to the 9-foot Project (OCE, 1970).

Project	Rivers and Harbors Acts	Work Authorized	Documents
4.5 foot	July 8, 1878	Adopted Project from St. Anthony Falls to Alton, Illinois	House Document 75, pt. 6, 43rd Congress, 2nd Session
5-foot	August 18, 1894	Extended project from St. Paul to Washington Ave. Bridge by construction of two locks and dams	Senate Document 109, 53rd Congress, 2nd Session
	March 3, 1899	Authorized completion of Lock and Dam 2 at Mile 850 and construction of Lock and Dam 1 at 847.6	House Document 164, 57th Congress, 1st Session
6-foot	March 2, 1907	Modification of Lock and Dam 1 for 6-foot channel, power development; abandonment of Lock and Dam 2	House Document 741, 61st Congress, 2nd Session
	March 2, 1919	Dredging a turning basis the full width and length of the Minneapolis Harbor	House Document 1512, 63rd Congress, 3rd Session
	September 22, 1922	Dredging to landings in main river and sloughs	None
	December 4, 1928	Modification of Minneapolis Harbor by dredging	House Document 24, 70th Congress, 2nd Session

847.6 and 850.0, and the Acts of 1899 and 1901 authorized completion of these facilities. The Rivers and Harbors Act of 1907 provided for raising the height of Lock and Dam 1 for the six-foot channel project and for power production. Construction was completed in 1917, resulting in the flooding and abandonment of Lock and Dam 2 at Mile 850.

The Acts of 1919, 1922 and 1928 authorized the dredging of the Minneapolis harbor and to landings in the main river.

This lock was rebuilt in 1930, after the lower miter gates of the original lock failed, to accommodate the newly authorized nine-foot deep channel, which was authorized by the Rivers and Harbors Act of 1930 as amended and by subsequent Acts.

MAPPING

Numerous surveys of the Mississippi River have been made by the Corps since the mid-1860's. The Corps published a series of charts of the 4.5-foot channel project for the Mississippi River Commission (MRC Charts), showing river soundings, wing dams, bottom type and land use, from 1894 to 1907.

The six-foot channel, which was authorized by the Act of 1907, was surveyed by air in 1927. This survey, was published in 1930 as the "Brown Survey" and reissued as the "Flowage Charts" in 1933-34 in order to include land use.

In 1938 the Corps published charts of the survey of the new nine-foot channel, the "Continuous Survey", showing river soundings and sandbars. Several editions followed, as "Navigation Charts", and emphasized aids to navigation. The current(1972) edition is based on a 1964 aerial survey and presents updated information and a more compact format than the previous edition.

CORPS FACILITIES

Lock and Dam 1, which is the second oldest of 28 such facilities on the Mississippi River, is located at Mile 847.6 near the Ford plant and the Minnesota Old Soldiers Home. It was completed in 1917 as part of the six-foot project, and rebuilt in 1930 to accommodate nine-foot-draft vessels. A second lock was added in 1932 on the landward side of the original lock (See Figures 2 and 3).

The facility presently consists of (1) the two navigation locks; (2) a 574-foot fixed-crest dam,152 feet of which has been modified for hydroelectric power production (by the Ford Motor Company); (3) guidewalls, a control station, an observation platform, and related structures; and (4) bluff protection (See Figure 4). Total cost of this facility was $6,252,334, including the original lock and dam, bluff protection and recreation facility.

Locks

The old riverward lock was rebuilt in 1930 due to the failure of the lower miter gates in August 1929. Originally, a structure suitable for nine-foot-draft navigation was to be constructed based upon the design pool level for the new Lock and Dam 2 which was then under construction. However, due to probable seepage damages, interests in the South St. Paul stockyards area of Pool 2 obtained a court order limiting the elevation to which the pool could be raised to 685.7 m.s.l.* Later, in 1934, the court approved the raising of the pool to elevation 687.2, which was 1.9 feet less than its designed height. As a result, there is a depth of only 7.5 feet over the lower sill at flat pool or about 8 feet at normal tailwater elevation, hence the lock has had little use except for an occasional locking of pleasure boats, empty barges, or shallow-draft towboats.

When this riverward lock was built, its landward wall was constructed of

* Mean sea level, 1912 adjustment.

Figure 2. Aerial Photo of Lock and Dam 1
(S.P.D.-NCS, 1973)

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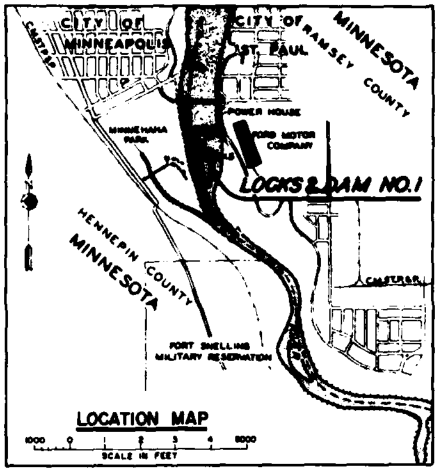

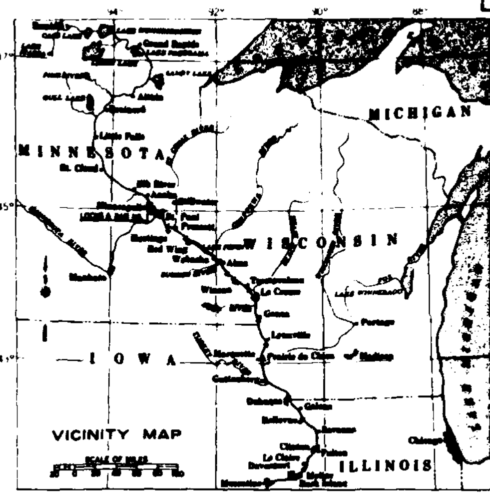

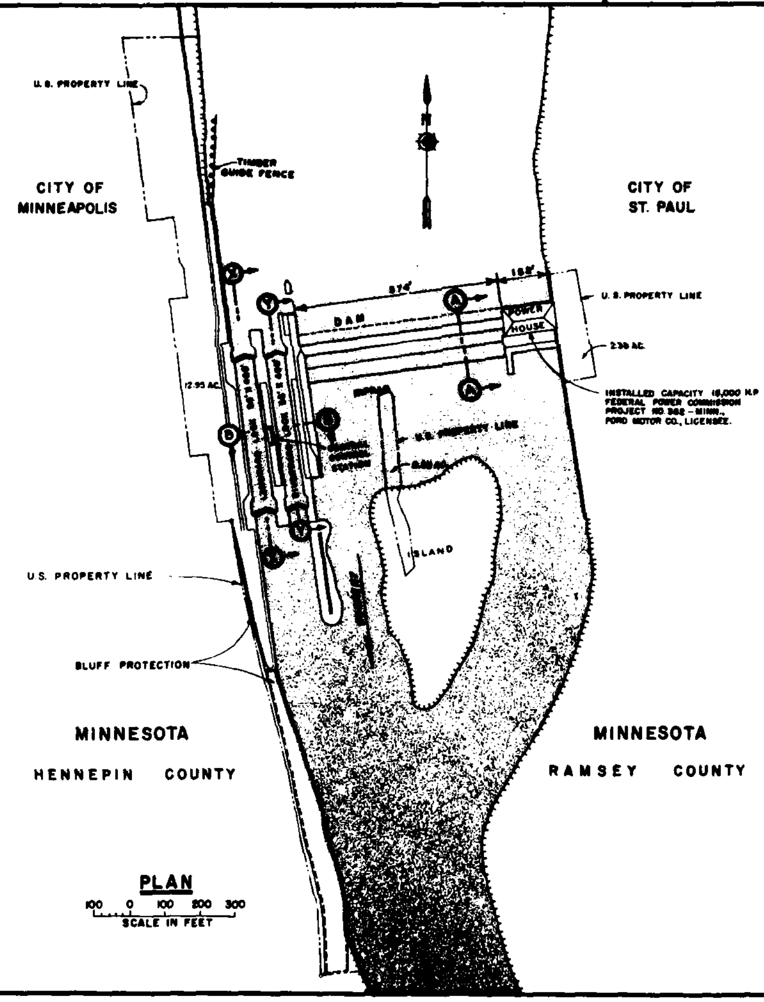

Figure 3

ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

	RIVERWARD LOCK	LANDWARD LOCK
DEPTH ON UPPER GATE SILL	** 13.4 FT. (U.P. EL. 723.1) * 12.4	13.4 FT. (U.P. EL. 723.1)
DEPTH ON LOWER GATE SILL	7.5 FT. (L.P. EL. 687.2)	10.0 FT. (L.P. EL. 687.2)
ELEVATION UPPER GUARD SILL	* 710.7	NONE
ELEVATION UPPER GATE SILL	709.7	709.7
ELEVATION LOWER GATE SILL	679.7	677.2

** POOL ORDINARILY MAINTAINED AT EL 725.1 BY FLASHBOARDS
* OLD UPPER GUARD SILL IN RIVERWARD LOCK ONLY

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCKS & DAM NO. 1

IN 2 SHEETS SHEET NO. 1
SCALE AS SHOWN

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST PAUL, MINN
30 JUNE 1966

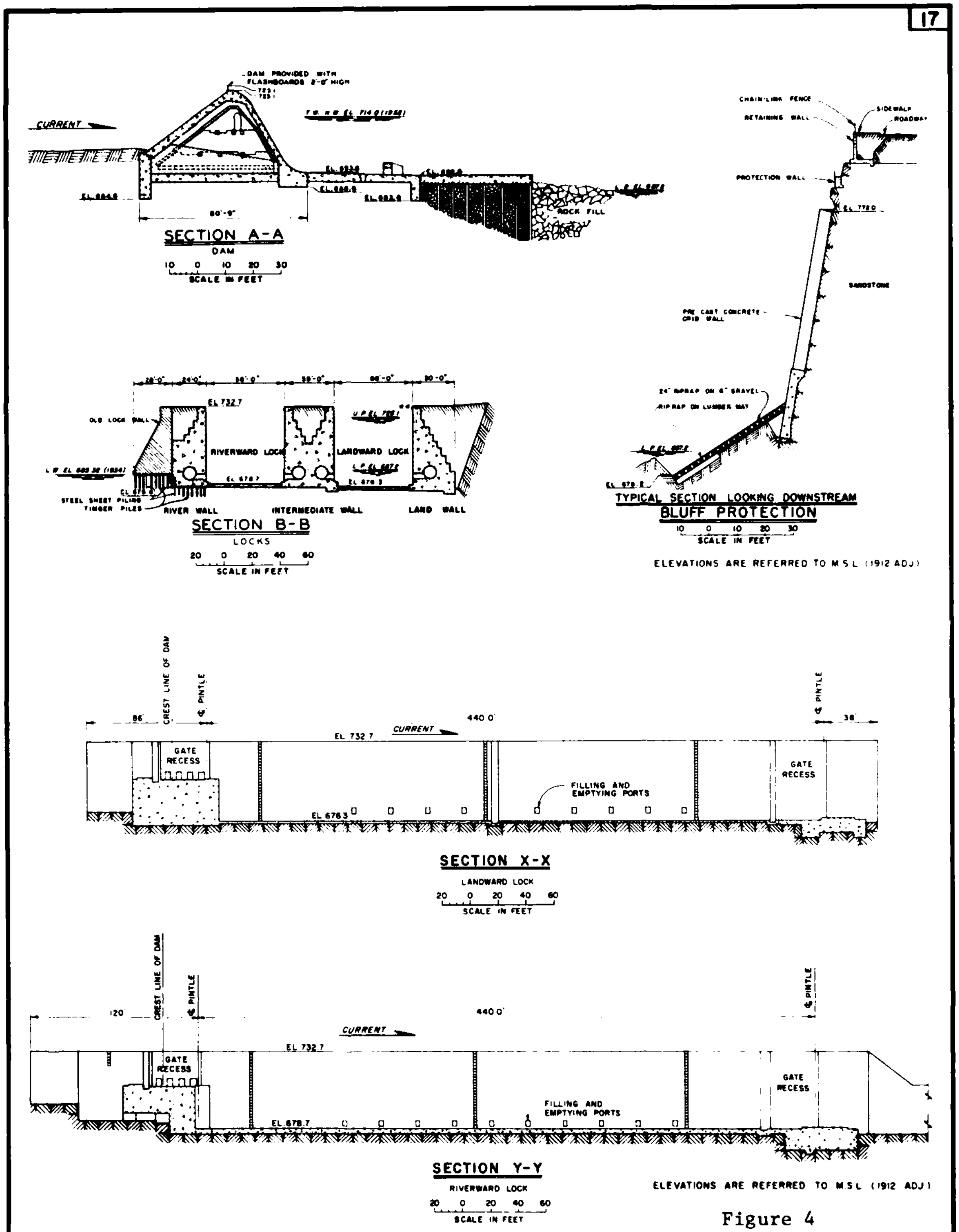

Figure 4

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCKS & DAM NO. 1

IN 2 SHEETS SHEET NO 2
SCALE AS SHOWN

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST PAUL, MINN
30 JUNE 1966

adequate width with two emptying and filling tunnels to serve also as the riverward wall of the second lock when it would be constructed. The landward lock was built in 1931-32 as a safeguard to maintain river traffic to and from Minneapolis. Minneapolis, as a result of the failure of the original lock, was without barge line service for over a year, and it was determined that a recurrence should be avoided if at all possible.

The downstream sill of the newer lock has a top elevation of 677.2, providing a depth of about 10.8 feet at normal tail water elevation; hence, this landward lock handles practically all traffic through this facility.

The original lock was to serve as an auxiliary, but now is kept half full in order to brace the weakened wall between the locks. Both locks are 56 by 400 feet. Each lock is closed by a pair of miter gates and the level changed 35.9 feet by gravity flow through filling and emptying ports (See Figure 4, Sections B-B, X-X and Y-Y) by a system of valves and pipes.

Due to the use of gravity for filling and emptying the locks, only a relatively small amount of electric power is required for the operation of the gates, valves and lights of the lock and dam.

Dam Description

The plan and sections for the dam are shown in Figure 3 and 4. The dam is an Ambursen-type concrete structure and for the greater part is supported on an alluvial fill consisting primarily of sand, gravel and limestone slabs. A portion of the dam and apron, however, is supported on timber piling. Along its upstream face is a steel sheet pile cutoff wall. There is also a row of steel sheet piling along the toe of the apron as a preventive measure against scour.

During maintenance, the crest and the downstream face was resurfaced (1949-53), and a major portion of the apron has been replaced and a baffle

wall was constructed on the apron to induce a hydraulic jump to overcome serious scour below the dam. This work was completed in 1953. In 1952 the dam was stabilized by placing sand fill in the interior to reduce the possibility of failure by sliding. Three of the eight sluice gates in the dam were rehabilitated and hydraulic machinery to operate them was installed in 1954. Under present pool conditions, the dam maintains a normal head of about 38 feet during the navigation season and about 36 feet during the winter season. In general, the dam is in good condition.

Winter Operations

In order to clear ice from gate pockets, an air bubbler system is provided at the upper and lower miter gates, and heaters have been installed on both miter gates. The heaters, in the side and bottom seals, consist of imbedded tubes containing a heated and circulated antifreeze solution.

Due to extensive erosion of the sandstone bluff and adjacent to the landward lock, it was found necessary to protect the exposed sandstone with a preformed concrete section retaining wall. Work on this wall was completed in 1956. A contract for 210 feet of protection of exposed rock above the masonry was completed in August 1965. A contract for a final 1,064 feet of protection was completed in November 1966.

Lands

Land in Pool 1 owned or controlled by the United States Government:

Fee title	32.80 acres
Flowage easement	263.67 acres
Total	296.47 acres

CORPS OPERATIONS AND MAINTENANCE

The project now consists mainly of the operation and maintenance of Lock and Dam 1, and the maintenance of the navigation channel by dredging of

accumulated sediment to maintain a minimum nine-foot channel, 200 feet wide. Occasionally the Corps also dredges the Minneapolis harbor at Mile 852.6.

Lock and Dam Operations

Lock and Dam 1 was built to the minimum elevation necessary to maintain low flow navigation of the channel, in order to minimize flooding of adjacent lands. The low dam elevation and small pool capacity relative to flood volume prevents operation of the dam for flood control.

Pool elevation is maintained at 725.1 feet above mean sea level (1912 adjustment) when the 2-foot high flashboards are in place. During the winter and floods, these boards are lowered, allowing pool elevation in winter to drop to 723.1 feet.

Locking Priorities

A priority system for vessels locking through has been established by the Secretary of the Army, as follows:

1. U. S. Military vessels
2. Vessels carrying U. S. mail
3. Commercial passenger ships
4. Commercial tows
5. Commercial fishing boats
6. Pleasure boats

Channel Maintenance

During the year, changes in hydraulic efficiency of the river (i.e., its ability to maintain in suspension continually its load of sediment) along the length of its channel results in areas of sediment accumulation in Pool 1. These areas are dredged by the Corps of Engineers to remove this hazard to commercial navigation, using clamshell dredges such as the Derrickbarge 767.

Dredging and spoiling are carried out by one of two procedures, depending on the proximity of the dredge site to the spoil disposal site on the shore. If the shore is within reach of the boom of the clamshell dredge, the dredged river sediment is cast directly upon shore. Alternatively, when the dredge is beyond reach of the spoil site, the sediment is cast into barges and towed to the spoil site (See Figure 5). At the spoil site the sediment is dropped back into the river by releasing the side gates on the barge (See Figure 6). The sediment is then redredged by another clamshell dredge (D.B. 771) and cast upon the spoil site, whereupon it is pushed away and levelled by bulldozers (See Figures 7 and 8).

Dredging to maintain the nine-foot channel in Pool 1 by the Corps began in 1938. It has since produced annually an average of over 125,000 cubic yards, or 22,000 cubic yards annually per river mile (See Table 3). This volume per mile is the highest in the St. Paul District (Table 4). Most of this sediment is spoiled either on the left (east) bank down from the Franklin Street Bridge, or on the right (west) bank downstream from the Lake Street Bridge. Apparently there is a trend to smaller volumes of sediment dredged in Pool 1 since 1954 (See Figure 9). However, in certain years larger volumes were produced, especially after the floods of 1965 and 1969. Another trend, evident in Figure 1 (Appendix A, IV), is the progressive downstream aggradation of the river bottom in Pool 1, and subsequent need for dredging. Thus dredging in the 1940's was necessary between Mile 850 to 853; in the 1950's, from Mile 849 upstream; and in the 1960's to present, from Mile 848 upstream.

The large volume of spoil removed from Mile 852 in the early 1950's is probably due to the construction of Lower St. Anthony Falls Lock and Dam and the floods of 1951 and 1952. The latter flood also necessitated the reconstruction of the Upper St. Anthony Falls Dam.

Changes in total area of islands, water surface and spoil were completed from 1895 and 1935 survey maps (MRC, 1895; Corps of Engineers; 1935), and from 1973 aerial photos (S.P.D.-NCS, 1973a). Between 1895 and 1932, during which

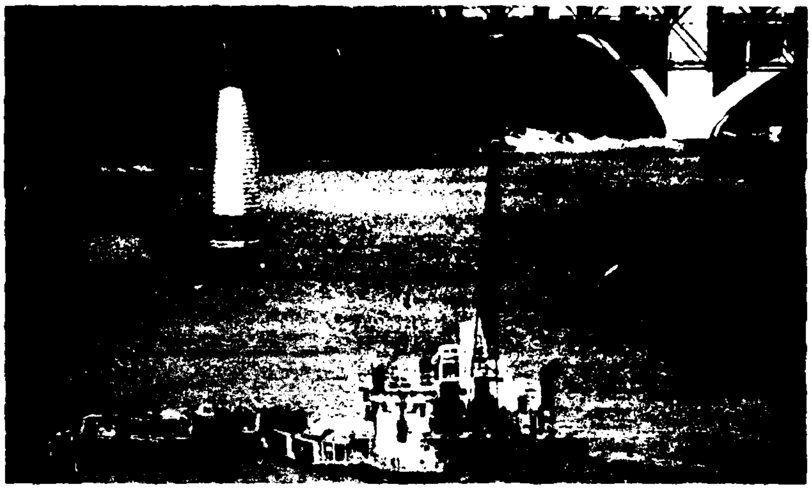

Figure 5. The Clamshell Dredge Derrickbarge 767 Deepening the Nine-Foot Navigation Channel on the Mississippi River. The spoil is Dropped into Waiting Barges which Transport it to the Spoil Site (Colingsworth)

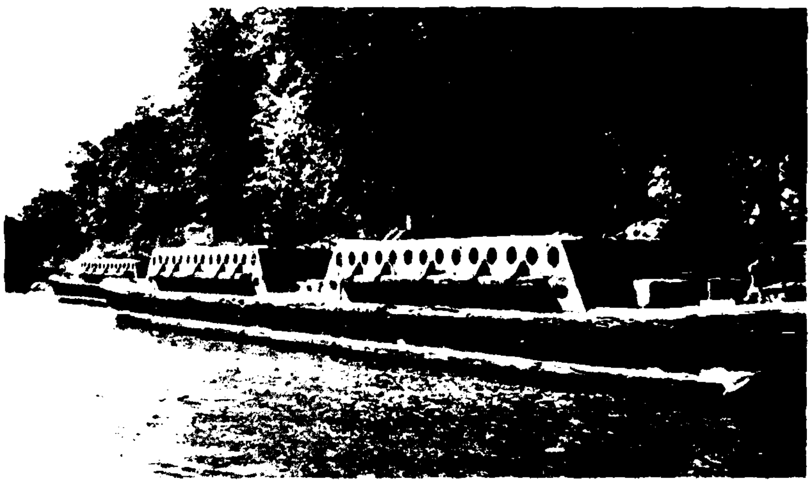

Figure 6. Spoil Barges Showing Side-Mounted Gates for Dropping the Spoil at the Spoil Site (Colingsworth)

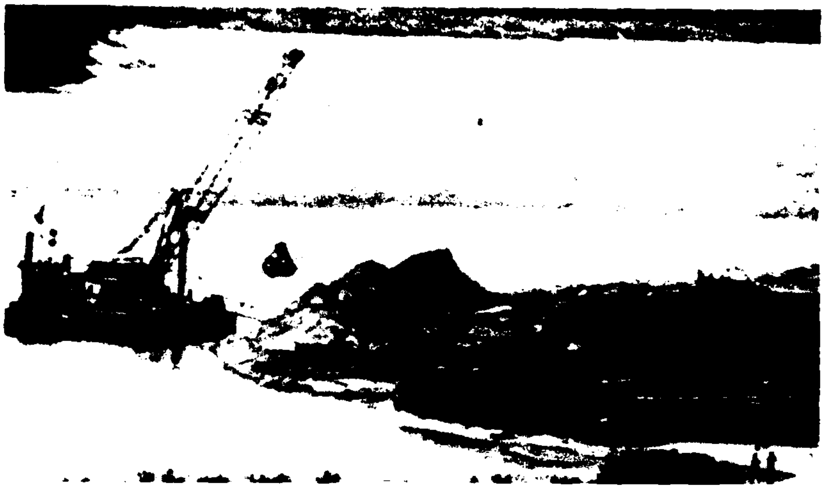

Figure 7. The Clamshell Dredge Derrickbarge 771 Redredges the Spoil Dropped by the Barges and Casts it onto the Spoil Banks. Note the Figures in the Right Foreground (Colingsworth)

Figure 8. The Newly Deposited Spoil Piles are Levelled by Bulldozer (Colingsworth)

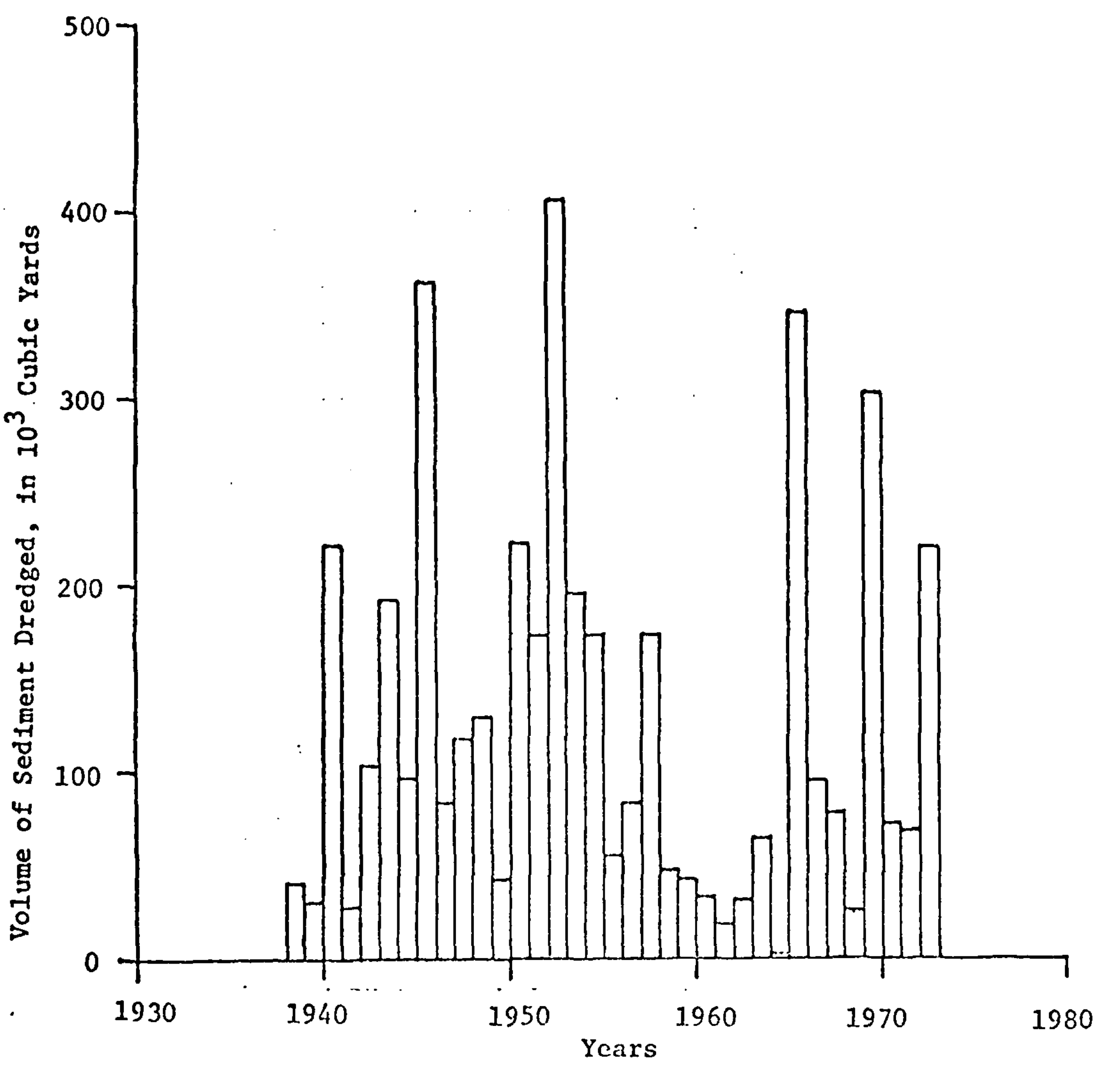

Figure 9. Annual Volume of Sediment Dredged from Pool 1 (S.P.D.-NCS, 1973)

Table 3. Annual Volume of Sediment Dredged in Cubic Yards, in Pool 1 from 1938 to 1972 (S.P.D.-NCS, 1973).

Year	Volume Dredged Cubic Yards	Year	Volume Dredged Cubic Yards
1938	40,518	1955	57,839
1939	30,864	1956	84,448
		1957	174,993
1940	221,314	1958	48,020
1941	28,381	1959	43,256
1942	103,378		
1943	192,271	1960	33,477
1944	97,464	1961	19,162
		1962	32,963
1945	361,840	1963	63,932
1946	85,005	1964	2,921
1947	118,321		
1948	129,434	1965	346,780
1949	42,131	1966	97,780
		1967	78,875
1950	222,056	1968	26,253
1951	173,702	1969	301,184
1952	406,076		
1953	196,991	1970	72,983
1954	173,870	1971	68,921
		1972	219,999
		Annual Average	125,640
		Annual Average/River Mile	22,042

Table 4. Quantity of Sediment Dredged per Year from the Mississippi River and Navigable Tributaries in the St. Paul Engineers District (Calculated from data from S.P.D.--NCS, 1973)

Pool or Tributary	Average Annual Volume Per Year (in cubic yards)	Average Annual Volume Per Year Per River Mile (in cubic yards)
St. Anthony Falls	23,522	5,470
Pool 1	125,640	22,042
Minnesota River	12,253	834
Pool 2	175,126	5,422
St. Croix River	40,836	1,667
Pool 3	112,187	6,130
Pool 4	487,836	11,062
Pool 5	235,969	16,052
Pool 5A	152,302	15,865
Pool 6	95,371	6,716
Pool 7	150,303	12,738
Pool 8	282,549	12,127
Pool 9	155,000	4,984
Pool 10	94,313	2,875
Total 14 — Total Annual Volume, St. Paul District	2,143,207	

Average Annual Volume per Pool 153,086

Average Annual Volume per Mile 8,856

time Lock and Dam 1 was built to its present elevation, the water surface area increased 104 percent, from 268.8 acres to 548.6 acres (Table 5). During this period the total area of islands decreased from 72.0 acres to less than 1 acre. Between 1932 (a drought year) and 1973 (during spring high water) the water surface increased 27 percent, from 548.6 acres to 695.7 acres, while spoil areas increased from 0 to nearly 46 acres. Presently there are no islands in Pool 1.

Bridges

Nine railroad and automobile bridges span the Mississippi River in Pool 1 (See Figure 1 in Appendix A,II). Seven of these bridges are located in the upstream, more urban-appearing portion of the pool, from the Milwaukee Road Railroad Bridge (near the Shriners' Hospital) and I-35W Bridge (adjacent to the Cedar Avenue Bridge). Vertical clearance of the bridges range from 29.4 to 101.1 feet above normal pool elevation (725.1 feet, mean sea level, 1912 data) (Table 6).

Table 5. Changes in area of water surface, islands and spoil in Pool 1 between 1895 and 1973

Year	Water Surface Area	% Change	Island Area	Spoil Area
1895	268.8		72.0	
		104%		
1932	548.6		1	
		27%		
1973	695.7			45.7

Table 6. Upper Mississippi River Bridges
Pool 1, Mile 847.6 to 853.3
(S.P.D.-NCS, 1969)

Miles Above Ohio River	Bridge Location	Type of Struct.	Use (2)	Year Comp. (4)	Height (feet) (3) Above Project Pool Elevation (725.1) (1)	Owner
853.25	Mpls.-Cedar Ave. (I-35W)	Truss	H	Un.Const.(N)	--	Minn. Dept. of H.
853.15	Mpls.-Cedar Ave.	Conc. Arch	H-P	1929(R)	101.1	City of Mpls.
853.0	Mpls.-Nr. U. of Minnesota	Truss	R	1924	29.4	N.P. Railway
852.69	Mpls.-Wash. Ave.	Girder	H-P(5)	1965	70.1	Minn. Dept. of H.
851.8	Mpls.-Dartmouth Ave.	Girder	H-P	1964	64.87	Minn. Dept. of H.
851.5	Mpls.-Franklin Ave.	Conc. Arch	H-P	1923	93.9A	City of Mpls.
850.7	Mpls.-nr. Shriners' Hospital	Truss	R	1902	76.2	Milwaukee R.R.
849.9	Mpls.-St. Paul-Lake Street	Steel Arch	H-P	1888	78.2A	Mpls. & St. Paul
847.8	Mpls.-St. Paul-Ford Pkwy.	Conc. Arch	H-P	1927	85.8A	Mpls. & St. Paul

Operation of movable bridges is governed by Code of Federal Regulations, Title 33, Chapter II, Sections 203.555 and 203.560 (g) (13).

(1) All elevations are mean sea level (1912 adj.).
(2) H-Highway, P-Pedestrian walks, R-Railroad.
(3) A-Crown of arch.
(4) N-new bridge, R-remodeled.
(5) Pedestrian deck above vehicular deck.

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2. ENVIRONMENTAL SETTING

NATURAL SETTING

The present natural environmental setting includes the project from the construction of nine-foot channel in 1930 to the present because this is an ongoing project. The environmental setting without the project, in this case prior to project construction, must be reconstructed from published information.

Ecosystems

The ecosystems of the upper Mississippi River and its valley in Pool 1 may be divided into several reaches and into various components or subgroups for more detailed description. Thus, Pool 1 may be divided into two reaches: (1) the Upper Reach, that portion from St. Anthony Falls to just below the Washington Avenue Bridge in which the banks are crowded with buildings, bridges and industry; and (2) the Lower Reach, that stretches from just below the bridge to Lock and Dam 1, containing mostly undeveloped banks, recreational areas, and dredge spoil deposits (See Figures 10A and B, 11, 12 and 13A and B; also Figure 1 in Appendix A, IV).

The various elements of Pool 1 ecosystems have been divided into two aspects: physical and biological in this report. The first is the physical aspect, including geologic, climatic, and hydrologic components. The section on biological aspects or systems includes floral and faunal components as part of terrestrial and aquatic ecosystems.

It cannot be overstated, however, that such divisions disguise the often numerous and complex interactions between components within these river valley ecosystems as well as with components elsewhere in the watershed. Thus, wherever possible, the characteristics of components in Pool 1 will be discussed in relation to the Twin Cities area, as well as to the entire drainage basin. Interactions with areas outside of the basin may be dealt with in a very general manner.

Figure 10A. Aerial View Upstream of the Upper Reach of Pool 1, Showing the Location of Transect 1AA and the Barge Terminals on the West (Right) Bank of the Mississippi River Near the Washington Avenue Bridge (Colingsworth)

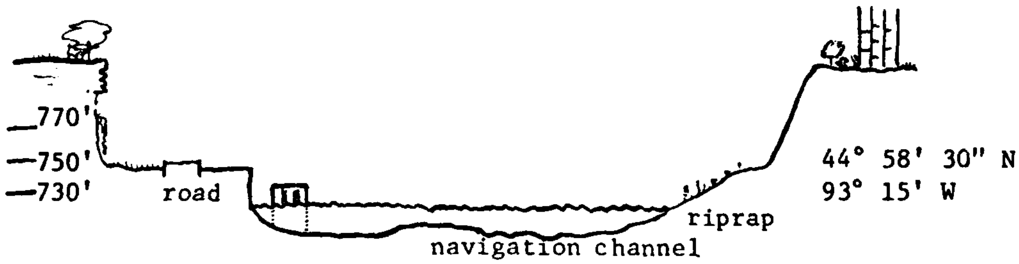


Figure 10B. Profile of Transect 1AA, Mississippi River Mile 853.1 (Gudmundson)

Figure 11. Aerial View Upstream of the Lower Reach of Pool 1. A Dredge Spoil Bank of the Mississippi River Downstream from Franklin Avenue Bridge

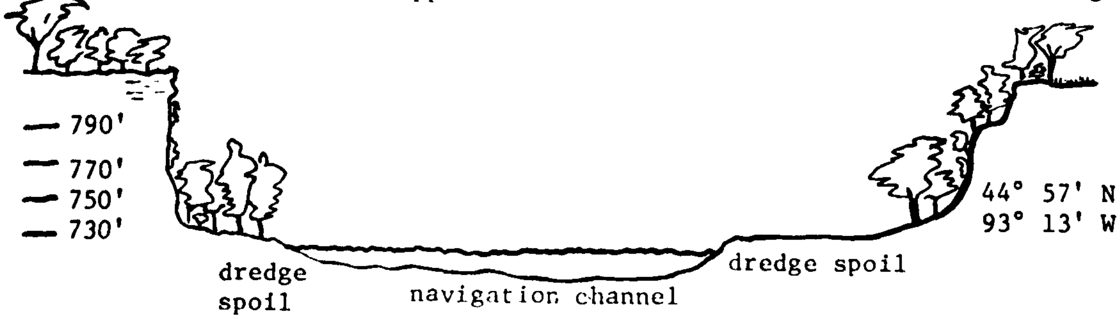


Figure 12. Profile of Transect 1BB, Mississippi River Mile 851.1 (Gudmundson)

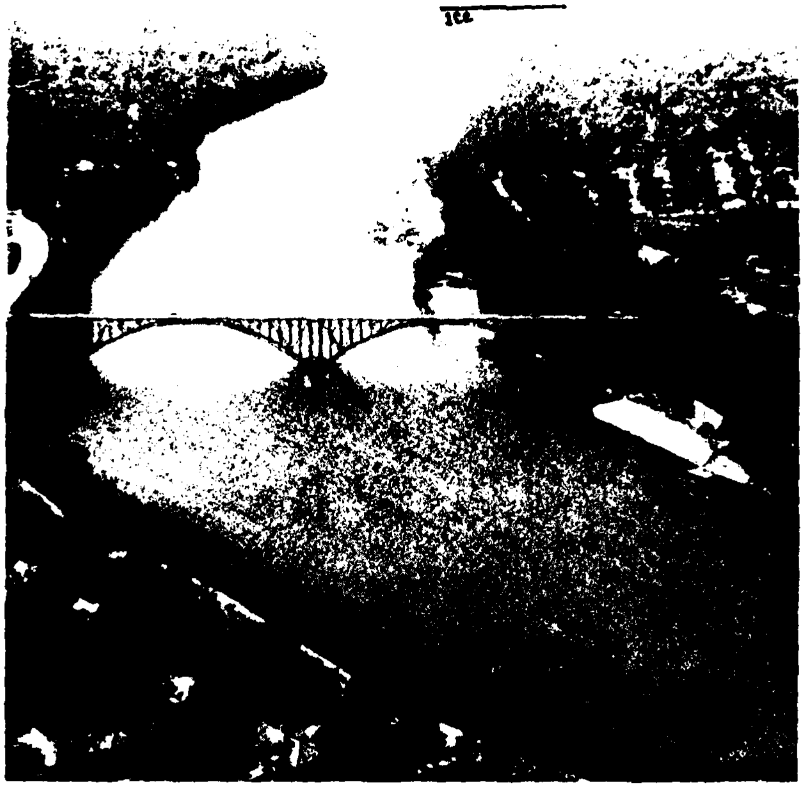


Figure 13A. Aerial View Downstream of the Lower Reach of Pool 1. Dredge Spoil Piles are Located on the West (Right) Bank at the Lake Street Bridge. Transect 1CC is Located just Upstream from the Ford Bridge in the Background (Colingsworth)

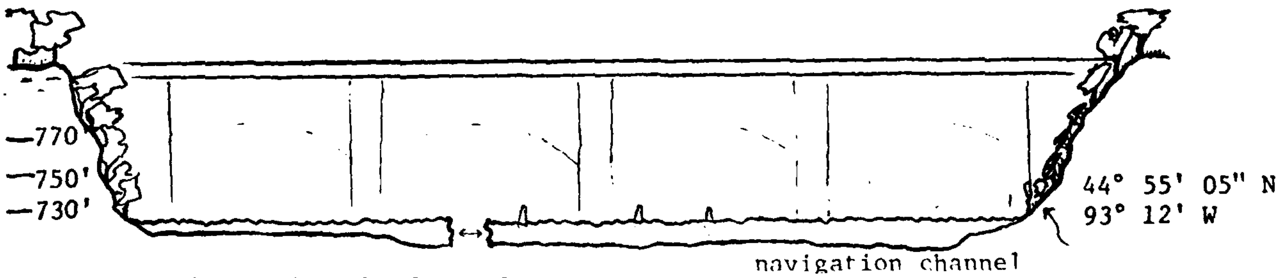


Figure 13B. Profile of Transect 1CC, Mississippi River Mile 848.0 (Gudmundson)

Physical Aspects

Topography and Climate

From its source in Lake Itasca downstream to Lock and Dam 1, the upper Mississippi River has a drainage basin of 19,700 square miles (Figure 14). This large watershed consists principally of level to rolling terrain. Scenic bluffs 100 feet or more in height occur along some portions of the River and its tributaries. The present topography is derived mainly from drift left by the Pleistocene glaciers and subsequently modified by erosion, plants and animals, and more recently, by man.

Presently the climate,which is moderately continental and grades eastward from dry subhumid to humid, combined with the influence of soils and man's activities,has led to a vegetation gradient. Thus the extensive mixed pine-hardwood forests bejeweled with numerous lakes and streams in the northeast, give way to former prairie--now productive, open farmland in the southwest dotted with marshes and laced with ditches and streams.

Upstream from the Twin Cities the Mississippi River meanders between banks 15 to 25 feet high through a broad but shallow glacial outwash valley. Then, at St. Anthony Falls it descends 75 feet and flows eight miles to Fort Snelling through a 100 feet deep gorge scoured out by those falls. Near Minnehaha Creek the Mississippi drops another 38 feet, at Lock and Dam 1. Downstream from Fort Snelling, where it is joined by the Minnesota River, the Mississippi is contained by another broader but deeper valley, once carved by a huge glacial meltwater river.

Geology

The upper Mississippi River watershed is underlain by a series of Precambrian igneous and metamorphic rocks north of Big Lake, Sherburn County, Minnesota. Downstream this basin is underlain by Cambrian, Ordovician and Devonian sandstones and limestones to the east and south, and by Cretaceous

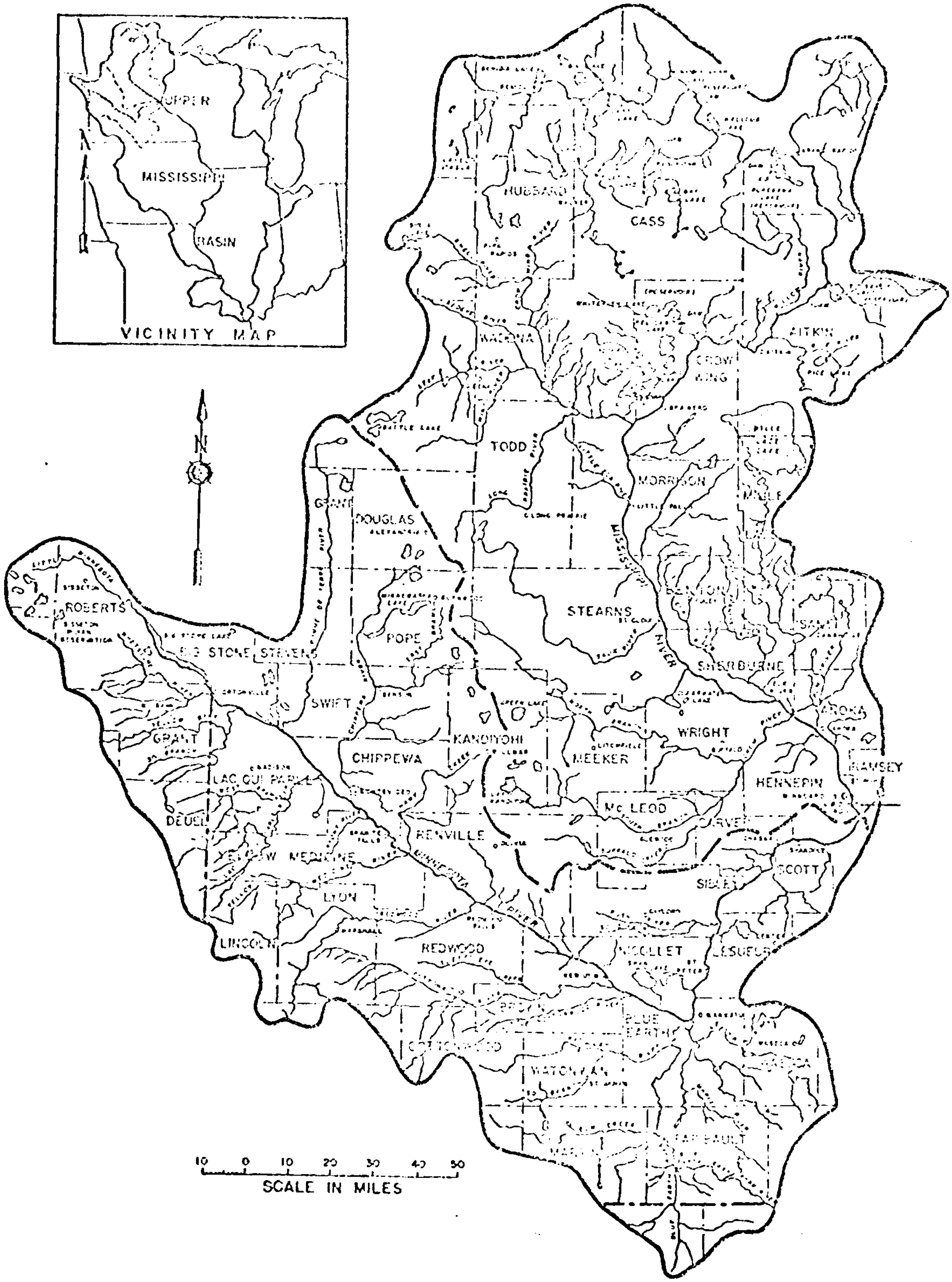


Figure 14. Upper Mississippi River Basin Above St. Paul, Minnesota (MNDNR, 1972)

shales to the southwest and beyond the watershed (See Figure 15 and Figure 16).

In the last million years at least four glaciers gouged their way across these rocks and through the Twin Cities (See Figure 17), then receded and left hills and valleys formed from drift or rocky debris which they had transported long distances. Deposits left by the last one, the Wisconsin Glacier, were brought in several phases, first from the northeast by the Superior Lobe (See Figure 18). This drift consists of red sands and pebbly deposits. Later the Grantsburg Sublobe of the Des Moines Lobe brought buff-colored sands, clays, and rock from the Cretaceous shales, more or less covering much of the previous deposits. Such deposits, if unstratified, are termed till; if transported and sorted according to size by glacial melt-waters, they are termed outwash.

These several glacial advances stagnated at various times and places in Minnesota and elsewhere, dumping huge mounds of rock, stone, gravel, sand and clay. The mounds were formed at the terminus of the glaciers and generally conformed to their shape; thus, they are termed "end" or "terminal" moraines. Terminal moraines and other tills and outwash, which have been subsequently modified by climate, vegetation and man, form our present soils and topography.

Most of Minnesota lies between 1000 and 1500 feet above mean sea level, with higher elevations in the northeast and southwest corners of the state as well as around the Mississippi River headwaters and in southern Ottertail County. Within the Mississippi River watershed, elevations below 1000 feet border the Mississippi River and its tributaries. Sharp relief occurs along the Mississippi, Minnesota and St. Croix Rivers where erosion has cut through underlying bedrock, forming sharp scenic bluffs.

The valley presently occupied by Pool 1 was formed during the northward recession of the Wisconsin Glacier over 10,000 years ago as the present floor of the Minnesota River's valley was being lowered by a great rush of glacial

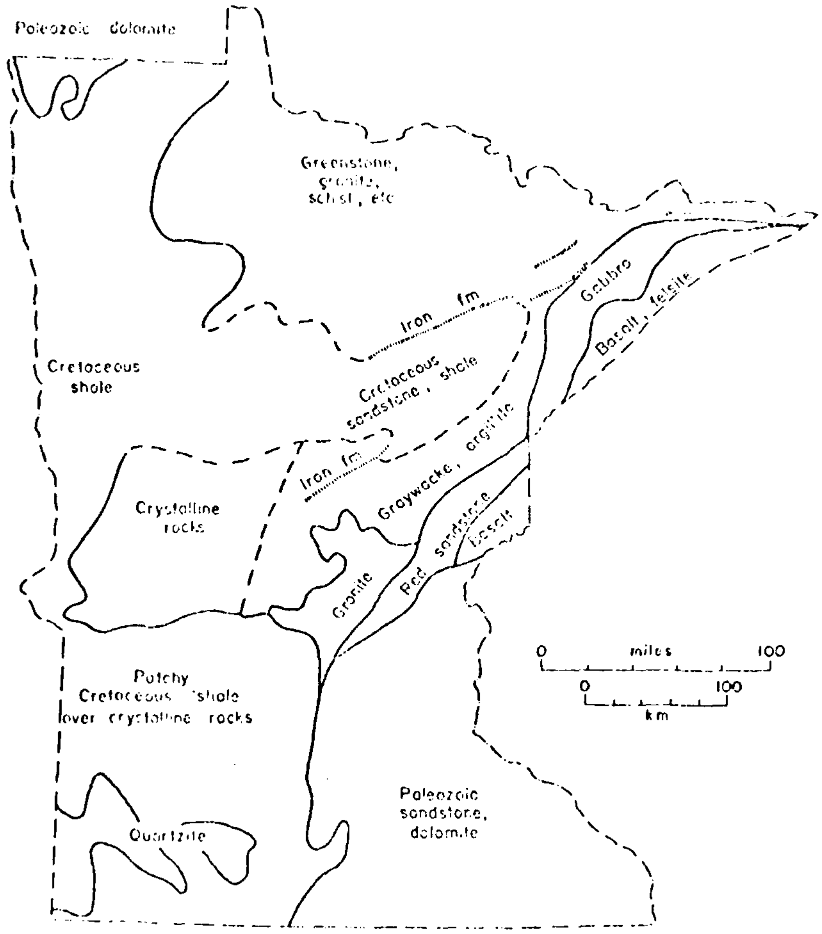


Figure 15. Bedrock Map of Minnesota (Minn. Geological Survey, 1969)

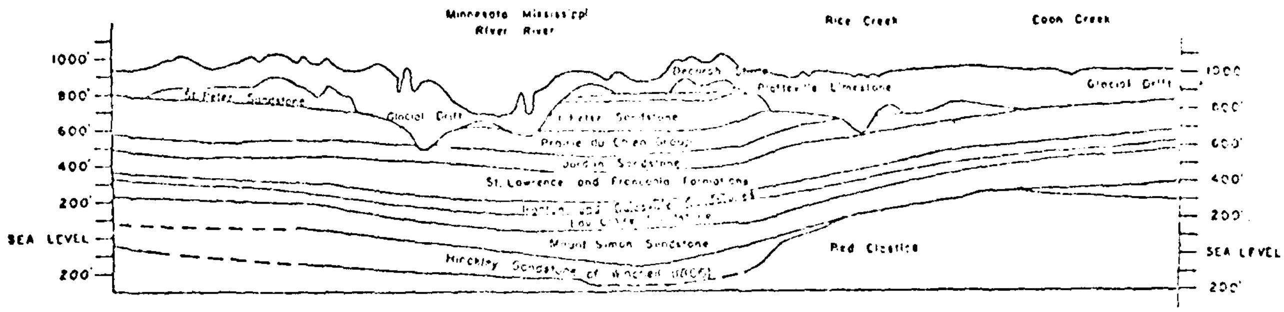


Figure 16. North-South Vertical Section thru the West End of Pike Island Showing the Twin Cities Artesian Basin (Winter and Norvitch, 1972).

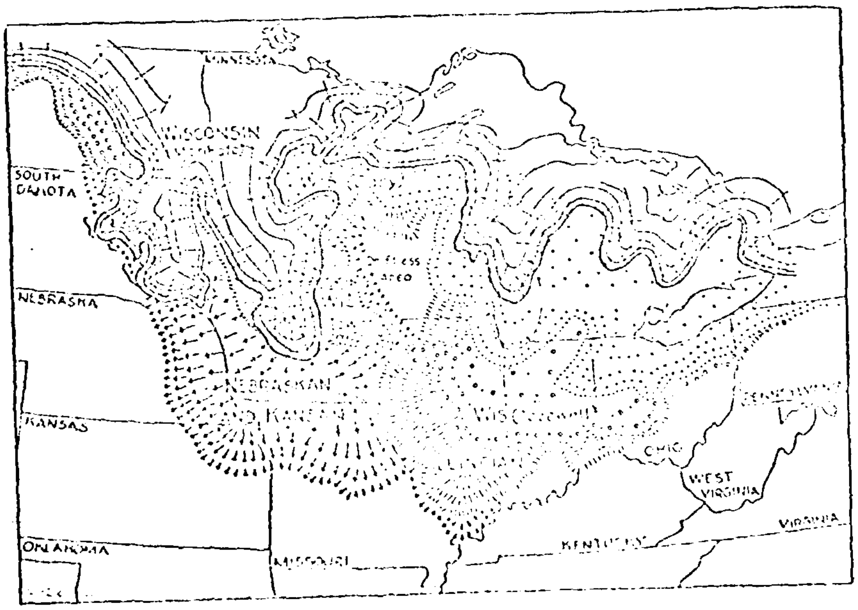


Figure 17. Map of Ice Sheets of the United States (Schwartz and Thiel, 1963)

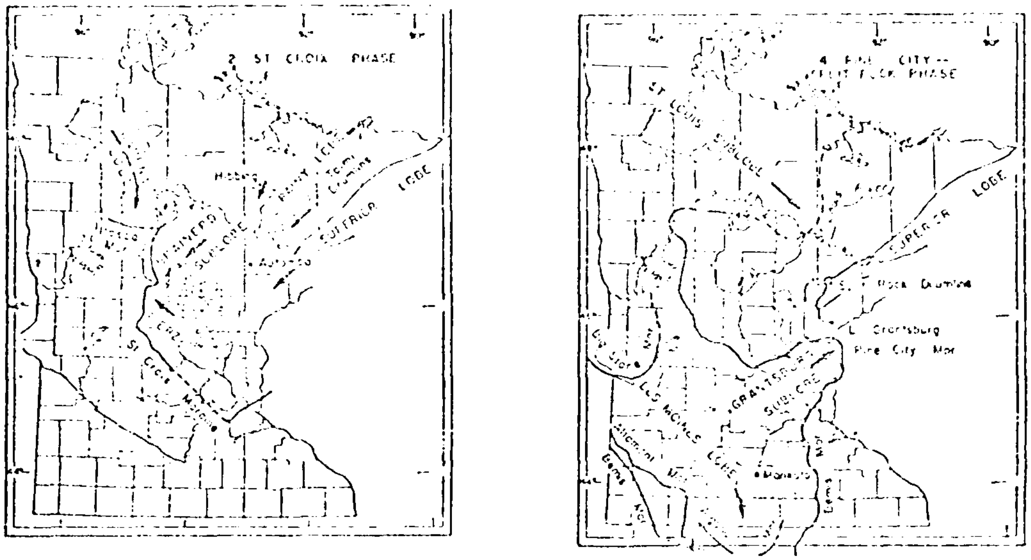


Figure 18. Maps of Minnesota Showing Extent of Ice Lobes During Various Phases of Wisconsin Glaciation (From Winter and Norvitch, 1972)

meltwater. This was the Glacial Lake Agassiz located to the west and north. Today, the Minnesota River and, downstream from Fort Snelling, the Mississippi River, meander through this broad and deep valley, 200 to 300 feet below the upland.

At St. Paul, near the present location of Holman Field, Glacial River Warren plunged over a rock ledge into a preglacial channel (See Figure 19); other preglacial valleys were apparently filled with sediment. This falls receded upstream to the site of the present Fort Snelling, where it divided. The main falls soon became extinct when it encountered another preglacial valley about three miles up the present Minnesota River. The St. Anthony Falls were born as the River Warren Falls eroded past a tributary: the present Mississippi River. Similarly, as St. Anthony Falls receded upstream from Minnehaha Creek, Minnehaha Falls began. As the larger St. Anthony Falls eroded the soft St. Peter Sandstone from under the harder Platteville Limestone, the deep gorge was formed in which now lies the present Pool 1. These

soft rock formations are exposed along the river bluffs in Pool 1. These and deeper formations dip about 20 feet/mile toward a low point on the Mississippi River just south of the University of Minnesota, forming the Twin City artesian basin (See Figure 16).

Climate

The climate in the upper Mississippi River basin varies from dry subhumid in the west to humid near Lake Superior, with the Twin Cities in the larger, moist subhumid central region. The average temperature varies from about 45°F. to less than 40°F. from south to north, while the normal total precipitation varies from less than 20 inches per year in the prairie to more than 28 inches per year in the northeast. About 20 percent of this precipitation falls between November and March. Average wind velocities range from 6 to 12 miles per hour with storm winds, especially tornadoes, greatly exceeding this. Generally the summer winds are southerly, bringing tropical air to the region, and winter winds bring arctic air masses.

Soils

The composition and depth of soil is a product of climate, vegetation and animals modifying parent material. Topography and exposure are also important.

The soils in the upper Mississippi River watershed vary from the northeastern well-leached (pedalfer) soils, which are typical of moist forests and have a shallow organic layer, to poorly leached (pedocal) soils having a deep organic layer in the prairie southwest. The Twin Cities soils are primarily pedalfer and vary from sandy clay loams on till to loamy sands which were deposited in slow-water reaches and a few small areas of clayey soils deposited in standing water (See Figure 20). Well-drained sites and northern exposures have lighter soils with less organic material.

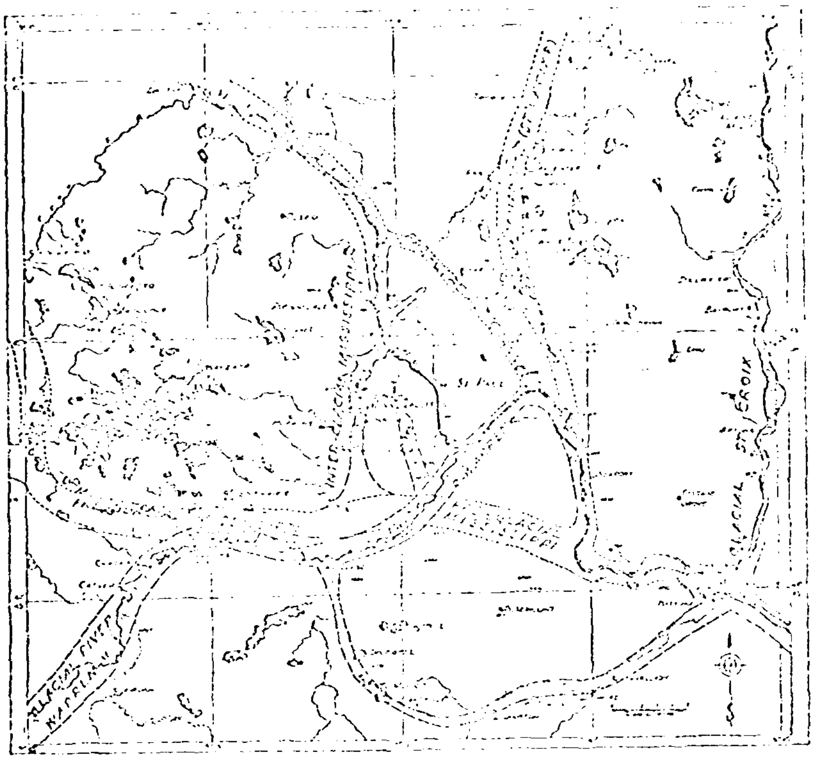


Figure 19. Map Showing Preglacial and Interglacial River Valleys of the Twin Cities Area (Schwartz and Thiel, 1963)

The soils along and on top of the bluffs in Pool 1 are generally medium and coarse sandy soils of variable thickness. These soils are characteristically well-drained, acid and low in nitrate and phosphate. The slope is under 12% and the percolation rate is generally less than 10 minutes per inch.

In the river valley, dark, organic river-bottom soils seasonally inundated and poorly drained are present only at the University river flats and lower portion of west Riverside Park. Other low, sandy soils occur as dredged spoil deposits at River Miles 849.50, 851 and 852.

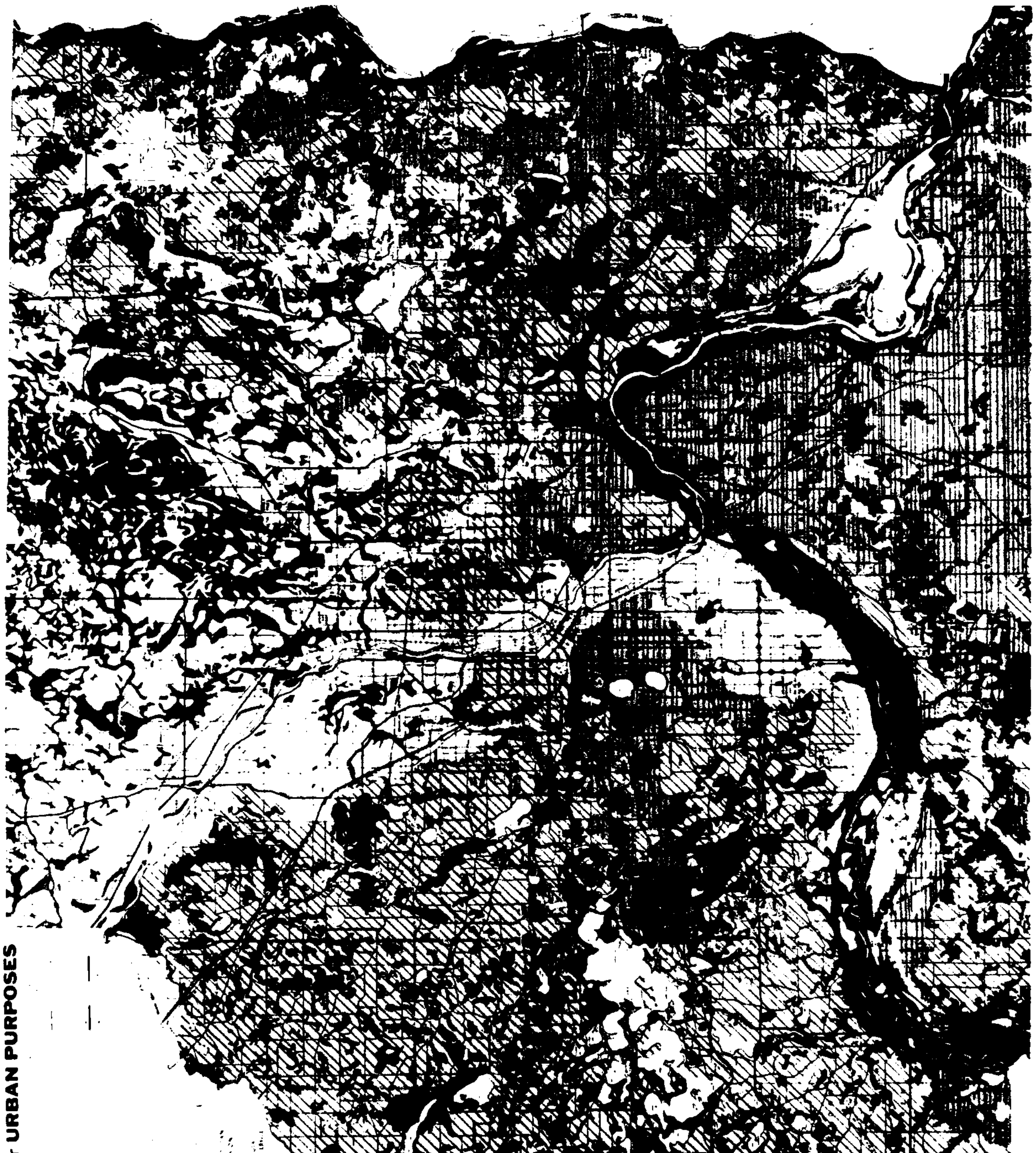


Figure 20. Soils Map of the Twin Cities Metropolitan Area (Hanson et al., 1967)

Groundwater

Large quantities of groundwater are present here in the highly permeable, surficial sand deposits. Many lakes and streams are located in these deposits. Rapid removal of groundwater from these aquifers generally induces water to move from the lakes and streams. These aquifers supply 95 percent of the water outside of the large cities. They are similar in chemical composition from the Mississippi headwaters to the Twin Cities, except that in the Cities they have only 1% to 10% of the iron content.

In the Twin Cities and 13 surrounding communities, the Mississippi River supplies the water. However, there are also a large number of wells in this area which are used mainly for industries and air conditioners. Total groundwater consumption was 200 mgd (million gallons per day) in 1970, estimated to be about 1/4 the total sustainable yield. The Prairie du Chien formation of Jordon Sandstone supplies about 75 percent of this water, while the Mount Simon-Hinckley Sandstones supply another 15 percent. The former aquifer supplies a medium hard water (average 412 ppm hardness as $CaCO_3$ in 1961) from 350- to 450-foot depths. It also contains more dissolved solids, sulfates, and bicarbonates, but lower iron and chloride than the lower (1000 foot) Mt. Simon-Hinckley aquifer (USGS, 1970).

Potentiometric studies (1970-71) of the water surface in the Prairie du Chien-Jordan aquifer in the Twin Cities indicate two groundwater recharge areas (See Figure 21). These include mainly southwestwardly inflow from an area bounded by White Bear Lake to just west of Afton. Southeastward and eastward inflow through Lake Minnetonka area constitutes the second groundwater supply to Pool 1.

Hydrology

Runoff in the upper Mississippi River basin varies from one inch in the westernmost extent to eight inches in the northeast, with four to five inches in the Metropolitan area. Evaporation is greatest in the southwest, at 34

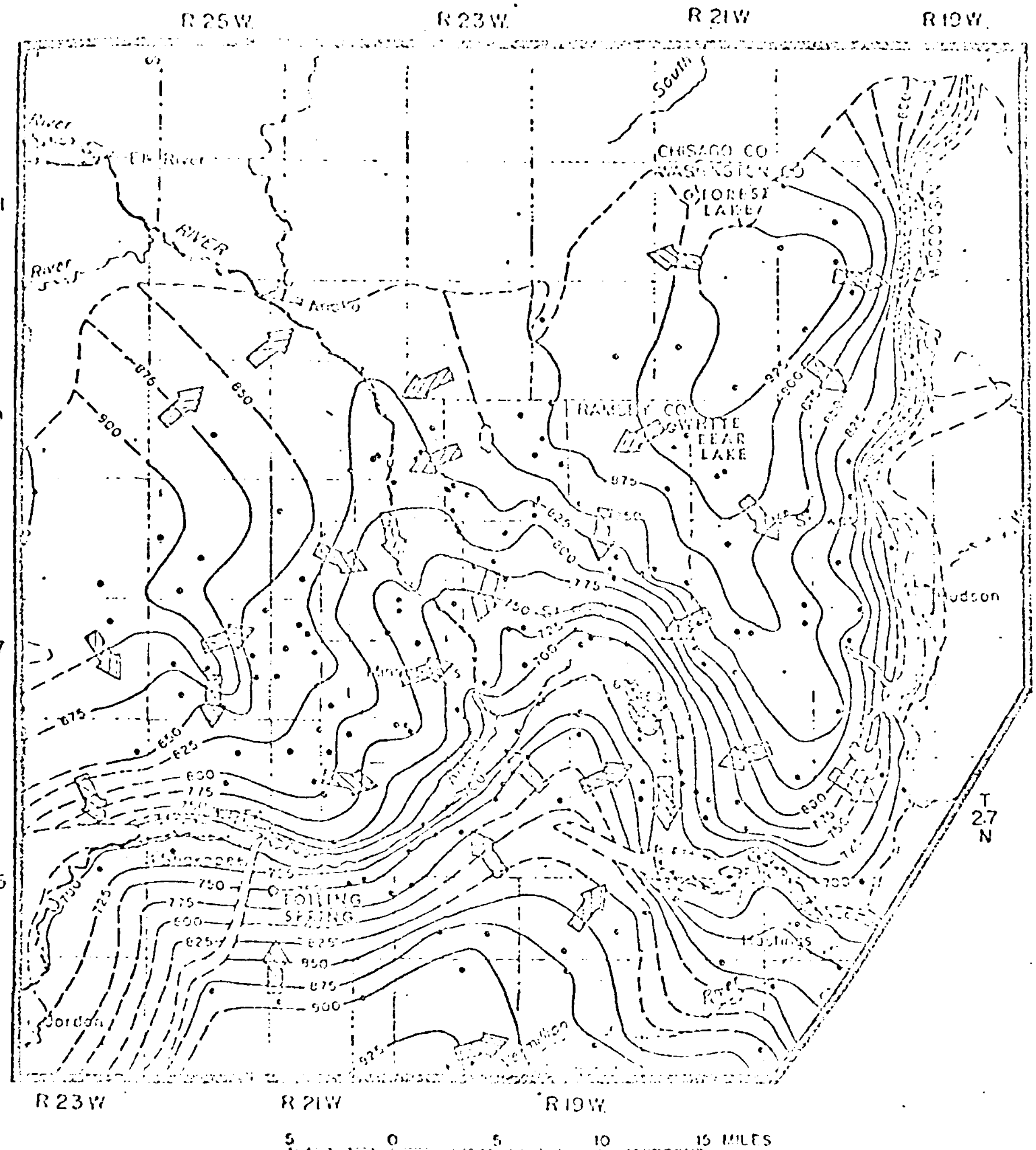


Figure 21. Potentiometric Surface of Water in the Prairie du Chien-Jordan Aquifer in Winter 1970-71, in the Minneapolis-St. Paul Area (Winter and Norvitch, 1972)

inches, and decreases to less than 24 inches in the northeast. The Twin Cities lose about 30 to 31 inches per year by evaporation. Some runoff is stored in six upstream reservoirs, built between 1881 and 1912 to augment low flow for navigation. After construction of the locks and dams and establishment of the nine-foot channel, this higher minimum flow was used to offset pollution.

Average (1907 to 1945) daily discharge of the Mississippi River at St. Anthony Falls is 5,510 cfs; this data provides a reasonable estimate since only a few intermittent tributaries enter Pool 1. Maximum discharge was 91,000 cfs in 1965 and the minimum was 462 cfs in 1934. The greatest discharge of record prior to construction of Lock and Dam 1 was 73,500 cfs in 1881.

The average water velocity in Pool 1 is about 0.5 mph at normal stage, but may reach 5 mph at extreme high discharge.

Since navigation is not feasible at discharges greater than 40,000 cfs, bridge clearances are based on the river elevation at this stage. The minimum horizontal clearance of bridges at this discharge is 160.0 feet and 32.4 feet vertically at the Northern Pacific Railroad Bridge at Mile 853.0.

Biological Aspects

Terrestrial Vegetation

The native vegetation in the Upper Mississippi River watershed located in Minnesota and western Wisconsin formed a gradient from tall-grass prairie in the southwest to deciduous (hardwood) forest to mixed deciduous-coniferous (hardwood and softwood) forest to the northeast (See Figure 22). Contact zones between the plant communities occurred as mosaics of peninsulas and islands rather than as distinct, separate belts. Climate, topography, exposure, soils, animals, fire and human history are important determining factors in vegetational pattern.

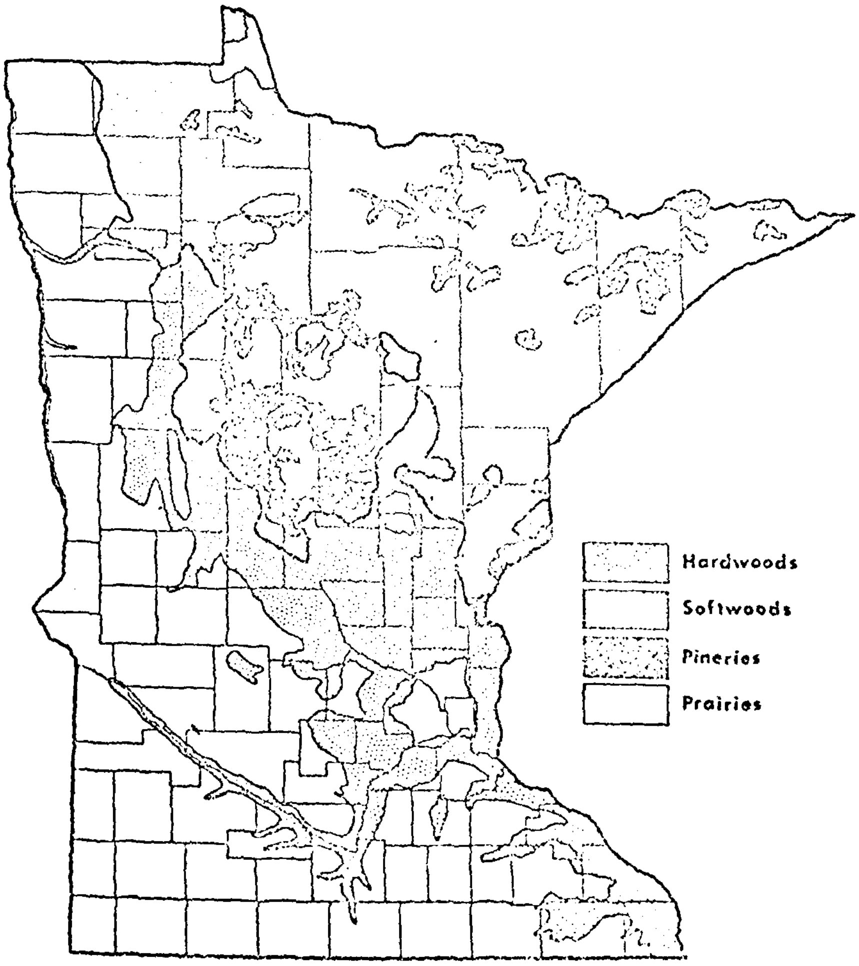


Figure 22. Present Day Forest Cover
(MN DNR, 1965)

The Twin Cities area lies in an island of prairie vegetation, where undisturbed, in a westward-extending peninsula of mixed deciduous-coniferous forest (Minnesota Department of Conservation, 1965). It consists of white pine, yellow birch, and maple on heavier soils, and red and jack pine on sandier sites. On sandy soils to the northwest of the Twin Cities, there is an island of the drier deciduous forest. Small to medium-sized oaks predominate in this forest.

West and south of these forests lies the tall-grass prairie region which included bluestem and bunchgrasses and a rich assortment of nitrogen-fixing legumes. This prairie has built up the soils of this area to a rich level of productivity. Urban and agricultural development has disrupted or removed much of this vegetation on the level uplands. A few small patches are preserved in the park area on the bluff top on the right bank of Pool 1. Sizeable segments of Phragmites-dominated prairie probably remain in drier bottom lands and steep-sloped terrain.

A cross-section from the river, across the floodplain and up the bluff face, shows vegetational zones representative of Pool 1 (See Figure 23). The vegetation changes from rich, moist grassy meadows and bottomland woods to northern hardwood forest, then dry upland forest near the top, to prairie grasses on the drier blufftop.

On the floodplain in the Twin Cities area, exposed sand and mud deposits become vegetated by herbs such as teal grass, millet, smartweed, and others (See Table 7, Wallace et al., 1969). This herb layer continues under the river bottom forest, which consists of elm, maple, willow, cottonwood, and other trees.

In Pool 1 the few acres of floodplain are located in the upper reach of the pool and are occupied by a park, parking lot or industry. On the left band of transect 1AA is the University of Minnesota's coal dock, behind which is a rocky slope, towered over by a cliff of Platteville limestone (See Figures 24 and 25; See Table 1 in Appendix A IV).

River Border	Meadow	River Bottom and Islands	Lower Slope	Upper Slope	Hill Prairie
Love-grass	Bluegrass	Peach-leaved willow	Basswood	Red cedar	Big bluestem
Sand-grass	Golden glow	Hackberry	Bitternut hickory	White oak	Little bluestem
Reed-canary-grass	Sedges	Green ash	Hackberry	White pine	Nodding grama
Rice cutgrass	Milkweed	Cottonwood	Ironwood	Sugar maple	Northern dropseed
River sedge	Aster	Silver maple	Bur oak	Paper birch	Hairy grama
Jewelweed	Blue-joint grass	Slippery elm	Shagbark hickory	Ironwood	Porcupine grass
Wild cucumber	Field horsetail	Amer. elm		Red oak	Leadplant
Cocklebur	Joe-pye-weed	Basswood		Bur oak	Ground plum
Beggar's ticks	Water-horehound	Bur oak		Hazelnut	
Canada wood nettle		Common nettle		Sumac	
Common nettle		River birch		Wolfberry	
White snake-root		Swamp white oak		Prickly ash	
Wild grape		Red maple			
Va. creeper					
Sandbar willow					
Peach-leaved willow					
Amer. elm					
Green ash					
Cottonwood					
Silver maple					

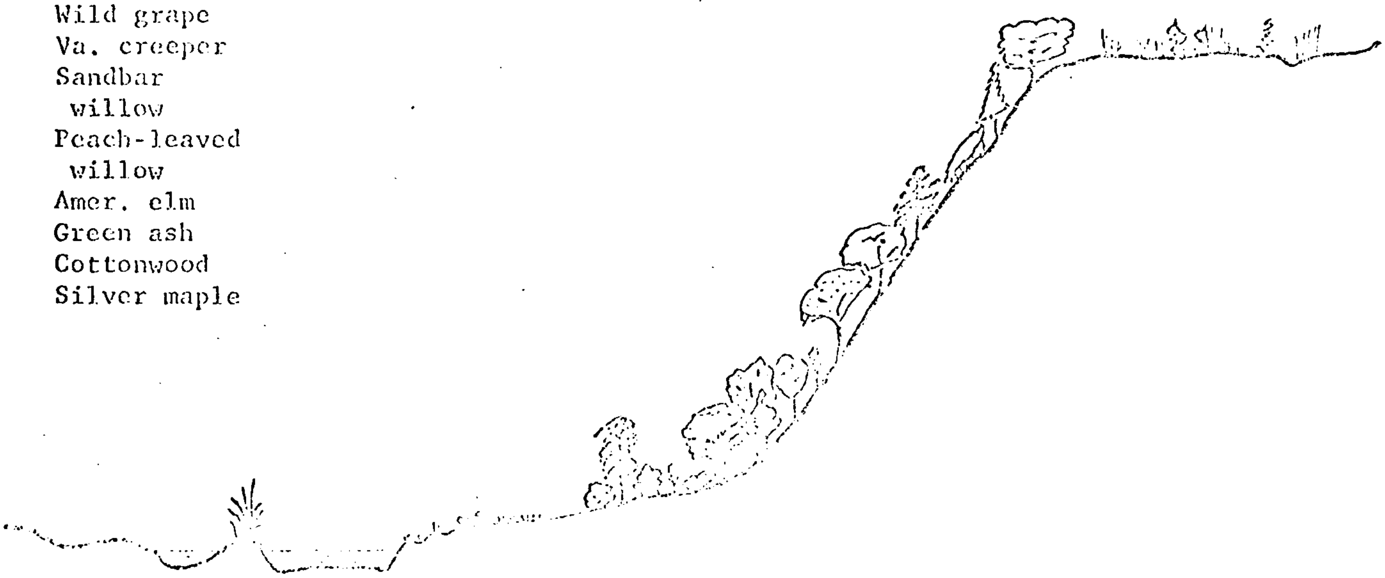


Figure 23. Typical Vegetation Zones Along a Transverse Section from the River to the Bluff Top (Lawrence and Gudmundson, 1973)

Table 7. Vegetation Common to the Habitats of the Upper Mississippi River Valley and Bluff Tops in the Twin Cities Area (Wallace, McHarg, Roberts and Todd, 1969)

Habitat Type	Occurrence and Species
Mudflats, sandy shores	Rare in the metropolitan area. Often included in the river-bottom category. Varies greatly. Some areas contain smartweeds, wild millet, fall panicum, teal grass and cocklebur.
River-bottom forest	Forests that occur adjacent to the rivers and mainly on floodplains. Woody: elm, ash, cottonwood, box elder, oaks, basswood, maple, willow, aspen, hackberry, with occasional pines and arbor vitae in the pine region. Herbaceous: some smartweed, wild millet, fall panicum, teal grass, and cocklebur.
Upland hardwoods (Big Woods and aspen-birch)	Woody: "Big Woods"--oaks (bur, white, red, and black), elm, basswood and maple dominant; with ash, hornbeam, aspen, birch, wild cherry, hickory, butternut, black walnut. Aspen-birch--eventually become hardwood forests, includes ash, elm, maple, basswood and oaks.
Dry oak savanna and dry uplands (oak openings, barrens and aspen-oak), and transition zones	Woody: oak openings and barrens--scattered trees and groves of oaks (mostly bur oak) of scrubby form with some brush and thickets and occasionally with pines. Aspen-Oak Land: aspen, generally dense, but small in most places, with scattered oaks and few elms, ash, and basswood.
Brush prairie	Grass and brush of aspen, balm-of-Gilead and a little oak and hazel in the north; but mainly oak and hazel in the south.
Grassy meadows (prairie)	Willow prairie (prairie with clumps of willows), grass.

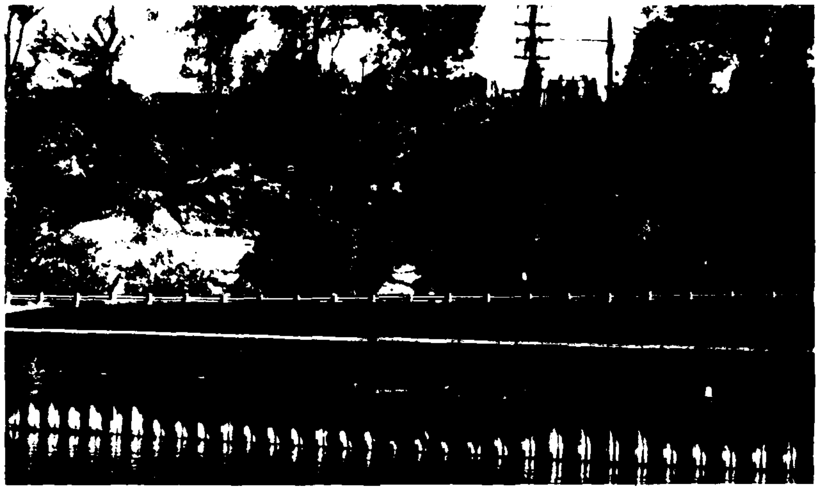


Figure 24. Left Bank of Transect 1AA, Mississippi River Mile 853.1. University of Minnesota Coal Dock is in the Foreground (Colingsworth)

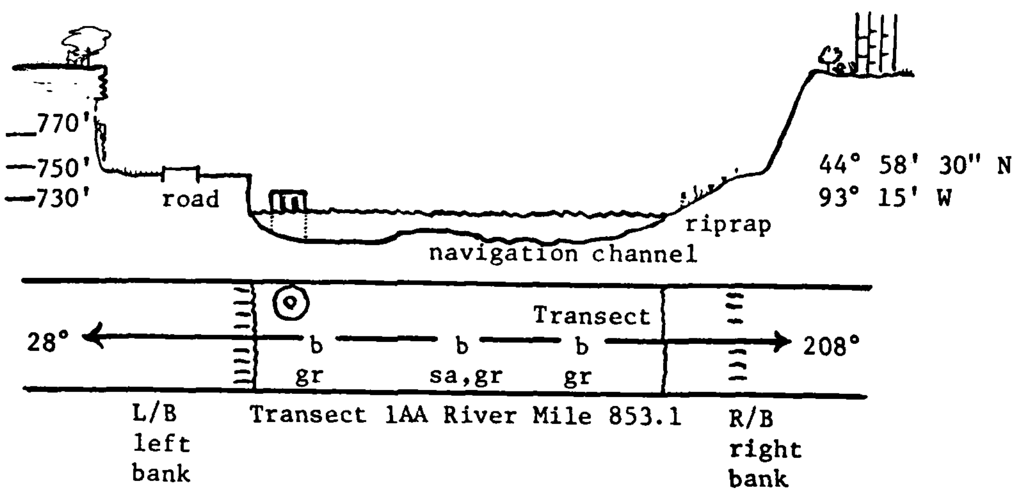


Figure 25. Plan and Profile of Transect 1AA, Pool 1 (Gudmundson)

Both riverbanks are covered by spoil on Transect 1BB and are nearly devoid of vegetation (Figures 26 and 27). Behind the spoil is a dirt and rock slope towered over by cliffs of St. Peter sandstone and Plattevillelimestone.

The left bank of Transect 1CC is similar to the banks at 1BB, but lacks the spoil (See Figures 28 and 29). The right bank consists of limestone blocks forming a sloping wall about six feet high, with vegetation penetrating the joints. Above this wall is a steep, grassy slope.

The bluff slopes have a variety of vegetation, depending on the density of the tree canopy and amount of disturbance. Cottonwood, river maple, box elder, red maple, green ash, basswood, and slippery elm are common tree species on these slopes (See Tables 8, 9 and 10). The 1CC transect also had bitternut hickory, paper birch, black locust and northern red oak. River grape and Virginia creeper are common under the denser tree canopy and were the only vegetation under the canopy on the left bank Transect 1CC.

More open canopy, such as on the right bank, Transect 1CC, has more variety, including staghorn sumac, sedges, grasses, daisy fleabane, field horsetail, false indigo, white sweet clover and milkweed.

Vegetation on Spoil

The zonation and succession of vegetation on the floodplain has been studied by George (1924) and on sandy spoil on the left bank downstream from the Franklin Avenue Bridge by Cooper (1947). George's study dealt mainly with plant succession on floodplain areas which produced three stages or communities:

1) the *Populus-Salix* community, consisting of pioneer cottonwoods, willows and several non-woody plants growing on open gravel flats which are flooded every spring but are very dry the rest of the year;

2) the *Populus-Acer* community, a forest made up of cottonwoods, surviving from the above pioneer community and the silver (river) maple, located on river terraces or old flood plains in moderately moist habitats; and

Figure 26. View Upstream of the Left Bank of Transect 1BB, Mississippi River Mile 850.6. The Spoil Pile is Located Just Upstream from the Abandoned Lock Visible to the Right Center. Trees Cover the Dirt and Rock Slope and the Brim of the Bluff (Colingsworth)

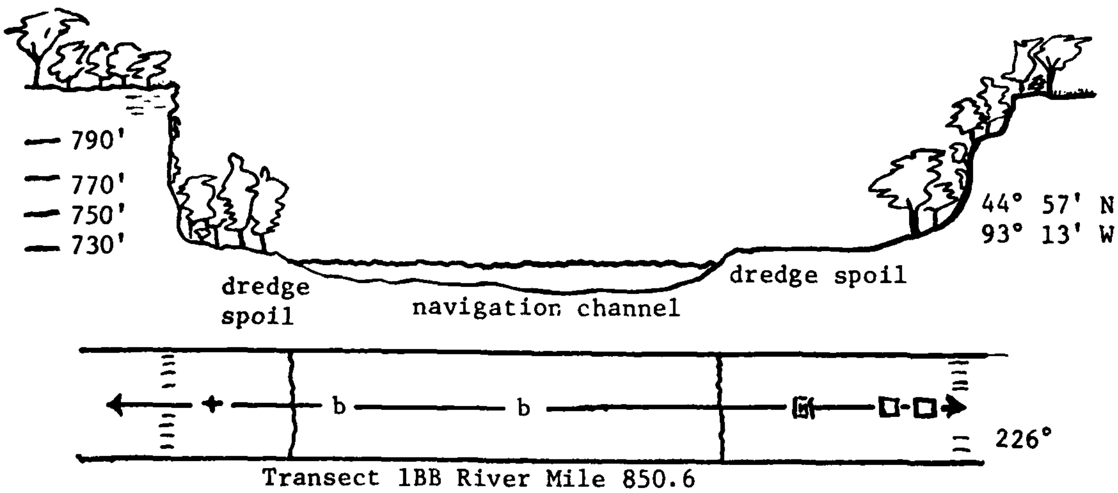


Figure 27. Profil and Plan of Transect 1BB, Mississippi River Mile 850.1 (Gudmundson)

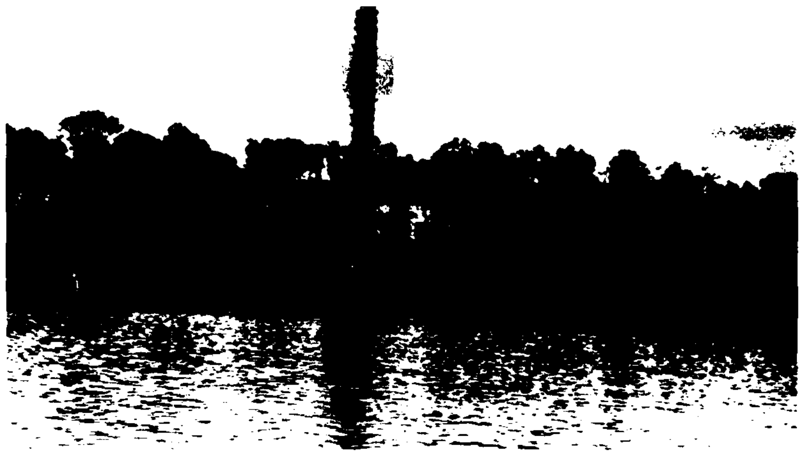


Figure 28. Left Bank of Transect 1CC, Mississippi River Mile 848.0 Showing Tree Covered Lower Slope and Exposed Sandstone and Limestone Cliffs (Colingsworth)

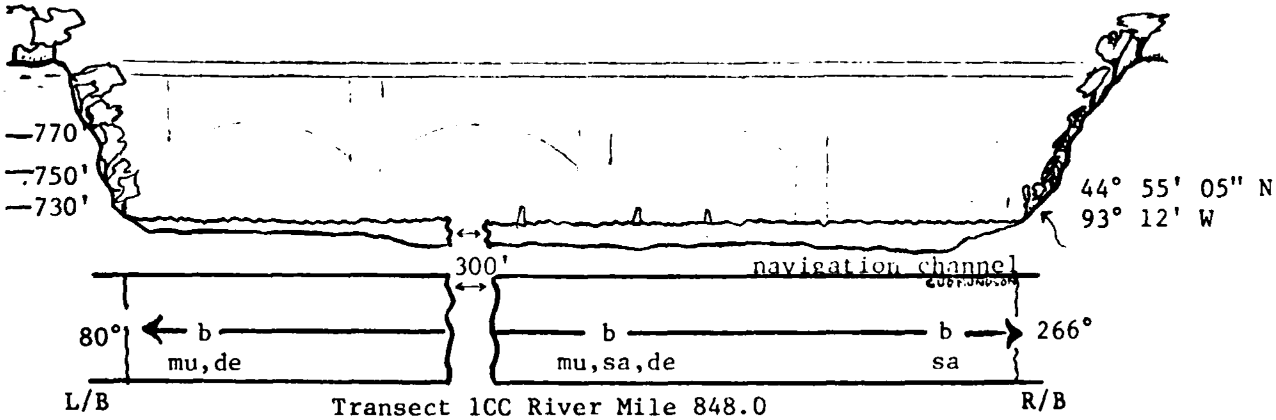


Figure 29. Profile and Plan of Transect 1CC, Mississippi River Mile 848.0 (Gudmundson)

Table 8. Plant Occurrence on the IAA Transect, Pool 1, Mississippi River Mile 857. (Colingsworth and Gudmundson, 1973)

Species		Left (east) Bank	Right (west) Bank
Cucurbitaceae	Cucumber family	P	
Parthenocissus inserta	Virginia creeper	P	
Gramineae	Grass family	P	
Solidago spp.	goldenrods	P	
Rhus sp.	sumac	P	
Populus deltoides	eastern cottonwood	P	P
Acer negundo	box elder	P	P
Fraxinus pennsylvanica,	green ash		P
var. subintegerrima			P
Acer rubrum	red maple		P
Asclepias spp.	milkweeds		P
Compositae	Composite family		P
Melilotus spp.	sweet clovers		P
Ulmus spp	elms		P
Cirsium spp.	thistles		P
Rumex sp.	sorrel, dock		P

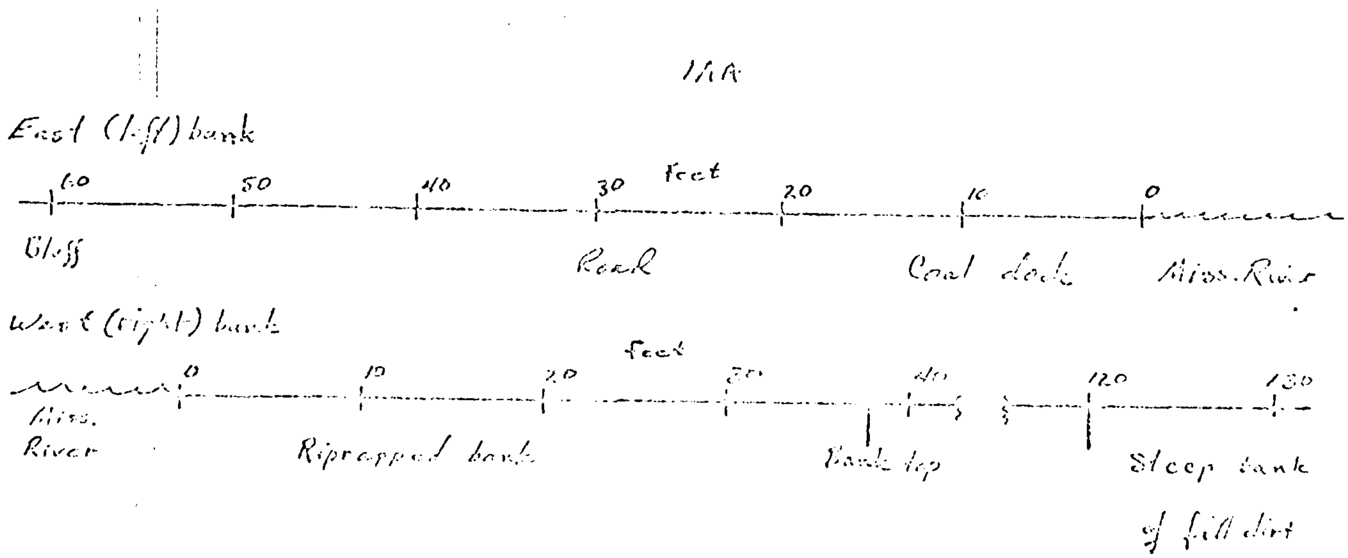


Table 9. Plant Occurrence on the IBB Transect, Pool 1, Mississippi River Mile 850.5. (Colingsworth and Gudmundson, 1973)

Species	West (right) Bank			East (left) Bank	
	Shore-line	Qd. #1	Qd. #2	Shore-line	Pt. Qtr.
Ulmus thomasi, rock elm	P				
Salix interior, sandbar willow	P				
Salix amygdaloides, peach-leaved willow	P				
Populus deltoides, eastern cottonwood	P		P		
Cycloloma atriplicifolia, winged pigweed		2%			
Verbascum ?, mullen		5%			
Elymus canadensis, Canadian wild rye		13%			
Setaria viridis, green foxtail		12%			
Taraxacum officinale, common dandelion		<1%			
Parthenocissus inserta, woodbrine		2%	10%		
Gramineae, Grass family			60%		
Lactuca sp., wild lettuce			P		
Vitis riparia, riverbank grape			P		
Solidago spp., goldenrod			P		
Sambucus sp., elder			P		
Morus rubra, red mulberry			P		
Arctium minus, common burdock			P		
Asclepias syriaca, common milkweed			P		
Eupatorium rugosum, white boneset			P		P
Ulmus rubra, slippery elm			P		25%
Glechoma hederacea, ground ivy					P
Tilia americana, American basswood					50%
Fraxinus pennsylvanica var. subintegerrima, green ash					25%
Leonuris cardiaca, common motherwort					P
Salsola tenuifolia, Russian thistle					P
Bare soil (sand)		60%			
Leaf, litter		10%	100%		

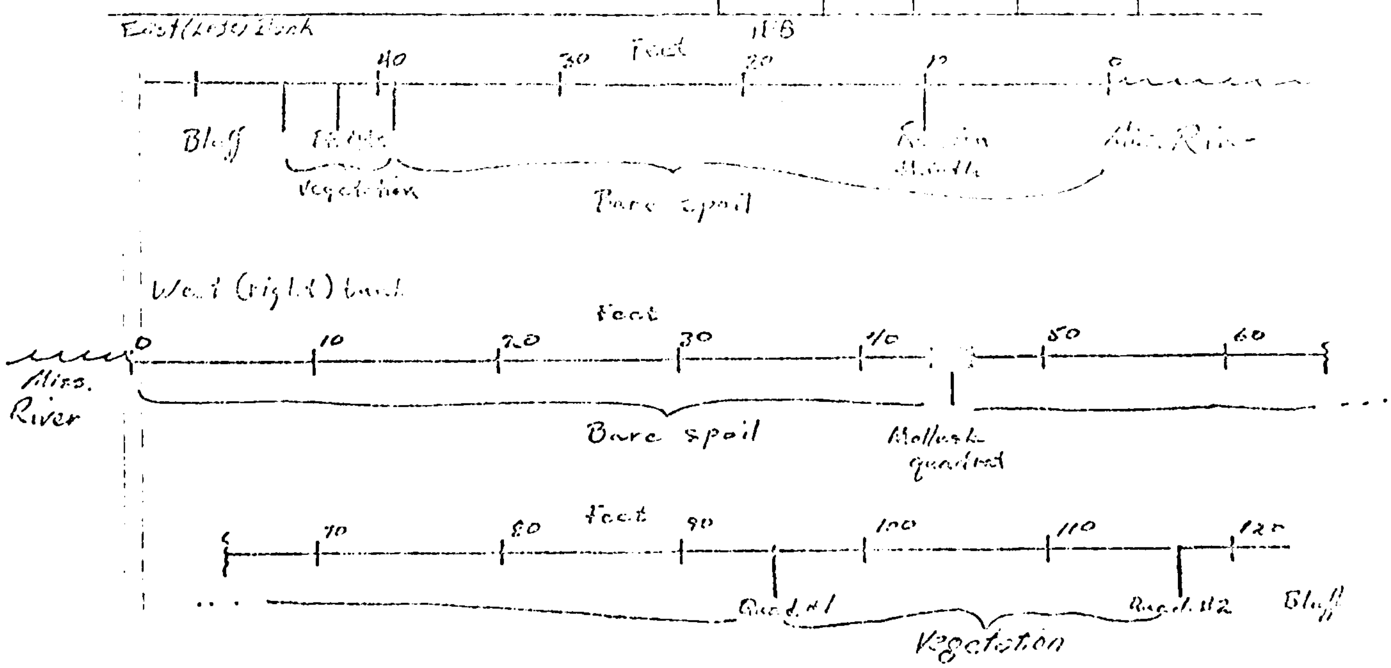
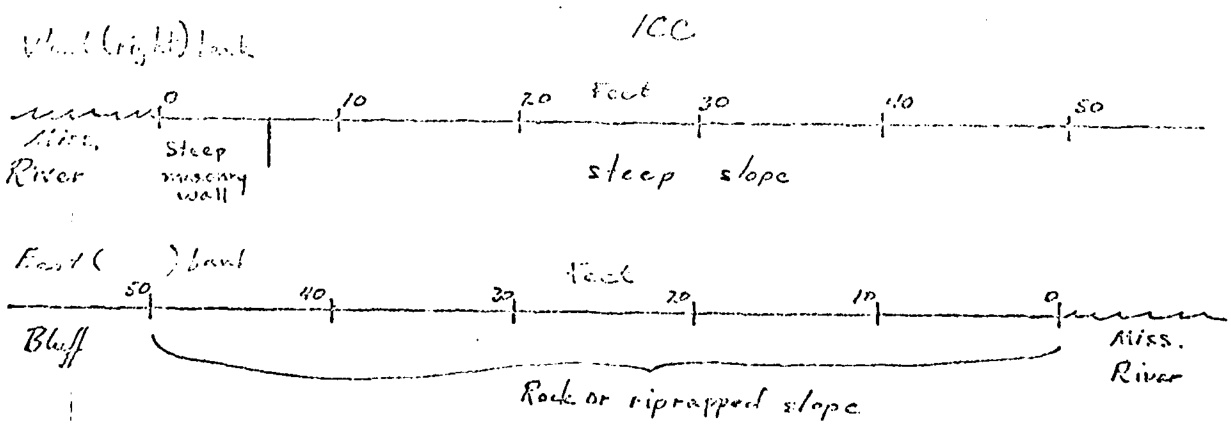


Table 10. Plant Occurrence on the ICC Transect, Pool 1, Mississippi River Mile 853.1. (Colingsworth and Gudmundson, 1973)

Species		Right (west) Bank	Left (east) Bank
Asclepias syriaca	common milkweed	P	
Rhus typhina	staghorn sumac	P	
Robinia pseudo-acacia	black locust	P	
Gramineae spp.	Grass family	P	
Quercus rubra var. borealis	northern red oak	P	
Eupatorium rugosum	white boneset	P	
Amorpha fruitcosa	false indigo	P	
Acer negundo	box elder	P	
Populus balsamifera	balsam poplar	P	
Cyperaceae	Sedge family	P	
Melilotis alba	white sweet clover	P	
Arctium minus	common burdock	P	
Erigeron annuus	daisy fleabane	P	
Salix interior	sandbar willow	P	
Equisetum arvense	field horsetail	P	
Populus deltoides	eastern cottonwood	P	
Acer saccharinum	river maple	P	P
Vitis riparia	riverbank grapes	P	P
Parthenocissus inserta	woodbrine	P	P
Fraxinus pennsylvanica var. subintegerrima	green ash	P	P
Tilia americana	American basswood		P
Ulmus spp.	elms		P
Betula papyrifera	paper birch		P
Acer sp.	maple		P
Carya cordiformis	bitternut hickory		P



3) the mature floodplain forest of the terraces, dominated by silver maple survivors from the Populus-Acer forest, American elm, and white ash.

During the earliest pioneer years, cottonwoods and willows grow together on the wet lower levels. Farther up and away from the water, the willow can grow only in fine soil which can retain much water or in moist sand, whereas the cottonwoods, with their larger root systems can reach down to the water underneath the higher dry coarse gravel areas.

Cottonwood seed germination is drastically affected by the time of flooding. For instance, a large crop of cottonwoods in 1922 was due to an extremely high flood that year, which receded and left a bare, moist soil just when the seeds were viable. The young seedlings of 1923, however, were completely destroyed by a rise of the water after germination. Because sandbar willows reproduce by runners as well as by seed, they are not subject to fluctuations in numbers to this extent.

More new information on floodplain succession would be useful: of the season of seed dispersal of the major floodplain species, the rate of decline of the spring floods, and time of deposition of spoil.

The species which will colonize dredge spoil during the season it is deposited depends largely on the date of deposition. If this occurs before July 15 in the Twin Cities area, and a thin layer of silt forms the uppermost layer about 6 to 8 inches above the water table, prompt establishment of tree seedlings can be expected, especially of cottonwoods, peach-leaved willow, American elm, box elder, silver maple, and the very important shrub: sandbar willow. This vegetation would provide enough cover immediately to improve the appearance of the spoil as early as the second year, and would reduce blowing of spoil sand into the backwaters or back into the channel.

The moisture gradient from the shore to the top of the spoil, as indicated by the depth of dry sand, apparently results in a zonation of the developing vegetation (See Table 11, Figure 30). Bare, saturated sand recently

Table 11. Vegetation Zones on Sandy Dredge Spoil (Cooper, 1947)

Vegetation: Common Name	Vegetation: Scientific Name	Zones* 1	2	3	4	5	6	7
Trees								
Cottonwood	*Populus deltoides*		P		P	P		
Peach-leaved willow	*Salix amygdaloides*		P					
Herbs								
Soft-stem bulrush	*Scirpus validus*	P						
Stick-tights	*Bidens* sp.		D	P				
Barnyard grass	*Echinochloa crusgalli*		P					
Love-grass	*Eragrostis* sp.			D		D		
Cocklebur	*Xanthium* sp.			P	D		P	
Bristly foxtail	*Setaria* sp.						D	
Strong-smelling clammyweeds	*Polanisia graveolens*						P	
Common saltwort	*Salsola kali*						P	D
Smartweed	*Polygonum* sp.						P	

* Abundance: D = dominant
P = present

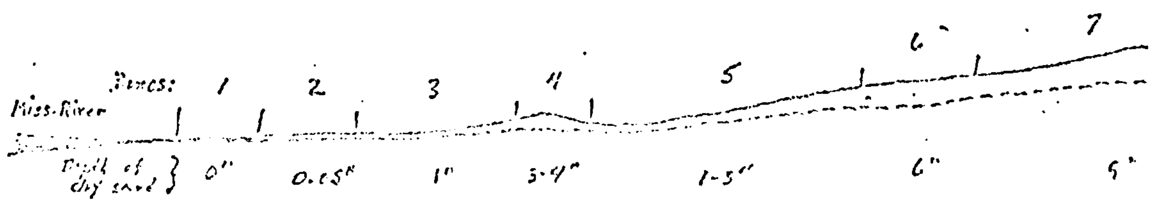


Figure 30. Vegetation Zones Along a Transect from the Mississippi River (in Pool 1) to the Top of Sandy Dredge Spoil (Cooper, 1947)

exposed by lowered water level (Zone 1) had a few patches of soft-stem bulrush (See Table 11). As the depth of dry sand increases away from the shore the dominant herb was sticktights (Zone 2), love-grass (Zone 3), and cocklebeurs (Zone 4). In Zone 5 the depth was similar to that of Zone 3 and correspondingly, love-grass was dominant. In Zones 6 and 7 the dry sand was successively deeper, with first bristly foxtail dominant, then a few scattered pioneers of mainly the common saltwort at the highest elevation. Bark fragments present in Zones 2 and 3 reduced moisture loss, encouraging the establishment of herbs. A few cottonwood seedlings occurred in Zones 2 and 4, and 1 to 2 year-old seedlings were found scattered in Zone 5, with the dry ridge top in Zone 4 and dryer Zones 6 and 7 lacking tree seedlings. Other sites studied by Cooper indicated that succession from the very moist (hydric) and very dry (xeric) culminated in the moderately moist (mesic) basswood and sugar maple bottomland forest (See Figure 31; See Table 2 in Appendix A IV).

The effect of moisture is also seen on the 1YY transect (See Table 12), located just downstream from the spoil site shown in Figure 13A. Near the shoreline stands a band of cottonwood saplings and a few river maple (See Figure 32). Behind the trees is a band of smartweed and cocklebur which gives way to love-grass and other grasses. Farther away from the shoreline the drier spoil supports only winged pigweed. After a bare area there are some scattered small willows; closer to the bluff sand-bar willows are numerous,and farther, cottonwood and elm. Basswood and cottonwood dominate a low moist area just below the west (right) bluff, perhaps an old spoil site. The herb layer beneath the forest canopy includes black nighshade, ground ivy, Solomon's seal, dandelion, burdock and nettles.

A comparison of photographs of spoil sites taken in 1956 and 1973 indicates that vegetation of spoil by trees near the water is indeed obvious after 17 years, however, no vegetation grows on the higher, drier sites (Compare Figures 33 and 11; and Figures 34 and 12). Revegetation is slowed by continued spoil deposition.

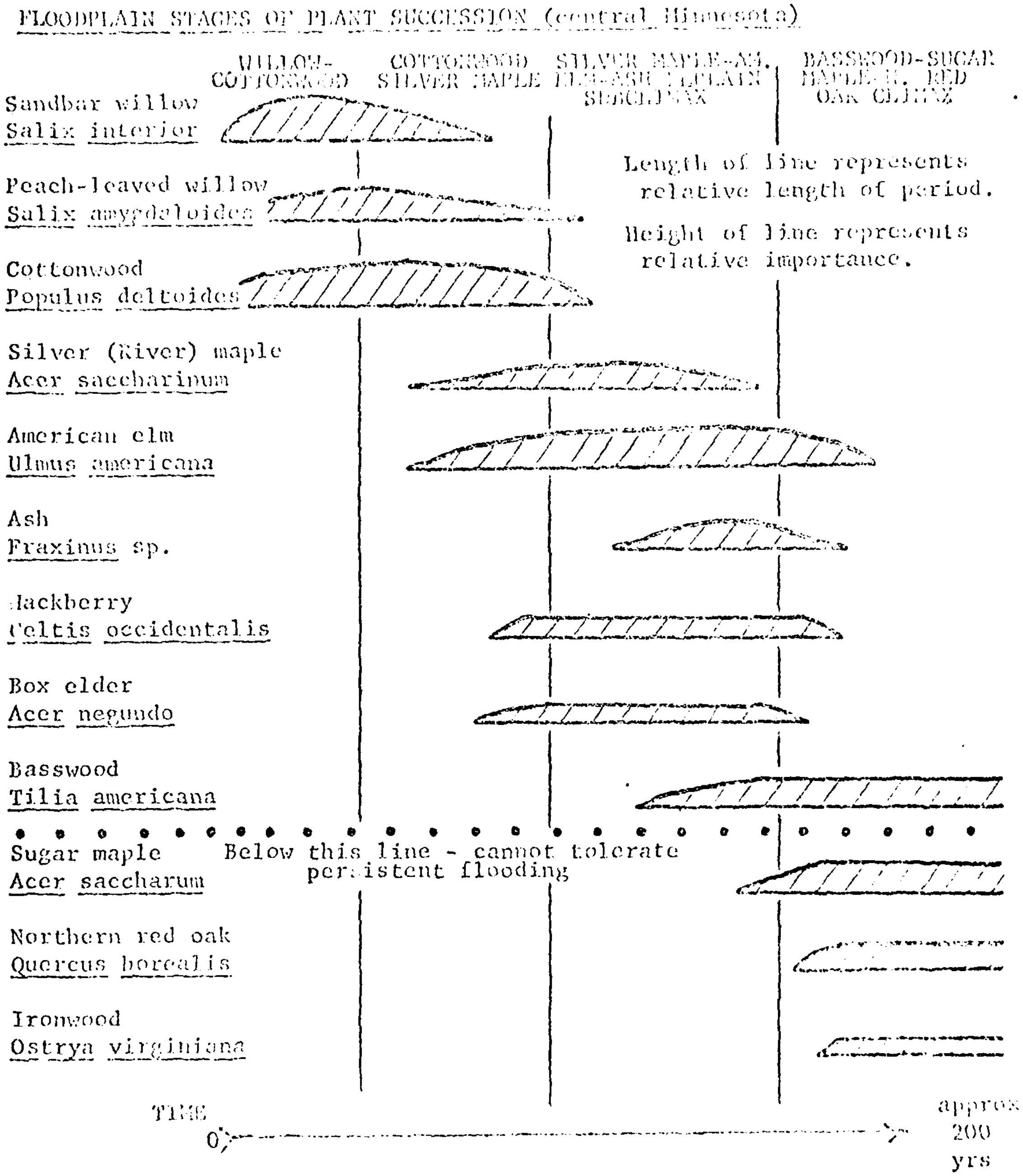


Figure 31. Stages in Floodplain Succession from Willow-Cottonwood to Basswood-Sugar Maple-Northern Red Oak Climax Forest (Adapted from Cooper, 1947)

Table 12. Plant Occurrence on Spoil, West (right) Bank Downstream from the Lake Street Bridge on Transect 1YY (Colingsworth and Senechal, 1973)

Species	Sta. #1 Pt.Qtr.	Sta. #2 Quad.	Sta. #3 Quad.	Sta. #4 Quad.	Sta. #5 Quad.	Sta. #6 Quad.	Sta. #7 Pt.Qtr.	Sta. #8 Pt.Qtr.
Glechoma hederacea, ground ivy								P
Solanum nigrum, black nightshade								P
Urticaceae, Nettle family								P
Polygonatum sp., Solomon's seal								P
Taraxacum officinale, dandelion								P
Arctium sp., burdock								P
Tilia americana, american basswood								7.5%
Acer saccharinum, silver maple	P							
Populus deltoides, eastern cottonwood	100%						25%	25%
Ulmus, spp., elms							25%	P
Salix interior, sandbar willow						90%	50%	
Salix spp., willows					70%			
Cycloloma atriplicifolia, winged pigweed			P	20%				
Corispermum hyssopifolium, heart-reed			P					
Eragrostis pectinacea, Pursh's love-grass		<1%	30%					
Polanisia trachysperma, clammy weed			2%					
Amorpha fruticosa, indigo bush			<1%					
Polygonum sp. #1, smartweed			P					
Polygonum spp. #2, smartweed			P					
Gramineae spp., grasses		P	30%					
Polygonum spp., smartweed		90%						
Xanthium italicum, cocklebur		35%						
Panicum capillare, old-witch grass		<1%						
Fraxinus pennsylvanica var. subintegerrima, green ash		P						
Medicago lupulina, hop clover		P						
Rorippa islandica, yellow cress		P						
Mentha arvense, peppermint		P						

Table 12. Plant Occurrence on Spoil, West (right) Bank Downstream from the Lake Street Bridge on Transect 1YY--Continued. (Colingsworth and Senechal, 1973)

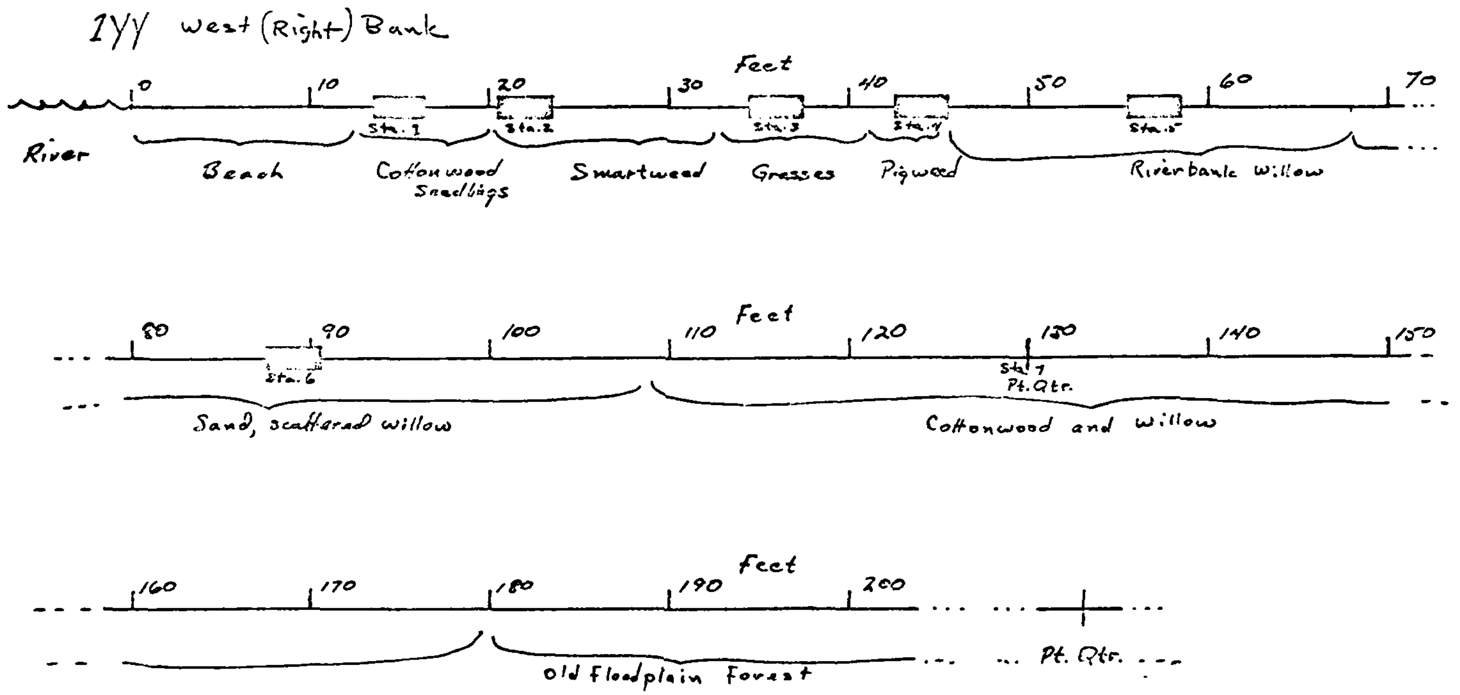


Figure 32. Zones of Vegetation on the 1YY Transect, Mississippi River Mile 849 (Senechal)

Figure 33. View Upstream in 1956 Toward Franklin Avenue Bridge, Showing Dredged Spoil Deposit on the Left Bank (Mile 851). Compare with Figure 11 Taken in 1973 and Note Increased Cover of Vegetation Particularly in the Nearer Sites Present after 17 Years.

Figure 34. View Upstream in 1956 Toward Lake Street Bridge, Showing Two Rather Small Spoil Deposits and an Apparent Older, Revegetated Site on the Right Bank (Mile 849.5 to 850). Compare with Figure 13A Taken in 1973 and Note Presently Increased Amount of Spoil.

Wildlife. Wildlife is diverse in the upper Mississippi River basin, varying from large mammals such as moose, bear, and deer to small furbearers such as mink and river otter (See Table 13). Also numerous geese, diving and dabbling ducks and other birds migrate through the watershed in Spring and Fall. More recent data (Wallace et al., 1969) suggests a wide diversity of animals in the Twin Cities area (See Table 14).

Few animals occur in Pool 1 other than insects, birds and man due to the lack of habitat, frequency of disturbance and roaming domestic cats. However, a beaver house with three individuals has been observed on the left bank at Mile 851.3, in a low area between two spoil piles at the outlet of a storm sewer.

Birds which have been reported in the Twin Cities area and their migration schedule is given in Table 4 in Appendix A, IV. About 280 species of birds have been sighted, of which 97 are common summer residents and nest in the area. Another 98 species are present in small numbers, often as spring and fall migrants. Irregularly seen bird species, i.e. single sightings, account for another 85 species. Probably considerable numbers of these birds frequent the varied and relatively continuous and undisturbed bluff and floodplain habitats in Pool 1. The trees along the bluff faces and tops, as well as on older spoil deposits contain numerous spring and fall migrants, and provide nesting sites for summer residents also.

Only one bird, a mallard, was seen in Pool 1 between April and November, 1973, compared with 130 birds upstream in the St. Anthony Falls pools and 243 birds downstream in Pool 2 (See Table 15). However, numerous other birds including sparrows, blue jays, grackles and robins could be heard in the trees which cover the bluffs.

The most significant difference between Pool 1 and the pools up- and downstream which may account for the low observed bird population, is the lack of protected backwaters such as at Nicollet and Hennepin Islands. Further study may reveal a larger songbird population in Pool 1 compared with

Table 13. Game Animals, Game Birds, and Furbearers of the Upper Mississippi River Basin, 1960 (FWS, 1970)

Moose	*Alces alces*
Whitetail Deer	*Odocoileus virginianus*
Antelope	*Antilocapra americana*
Black Bear	*Ursus americanus*
Snowshoe Hare	*Lepus americanus*
Whitetail Jackrabbit	*Lepus townsendi*
Swamp Rabbit	*Sylvilagus aquaticus*
E. Cottontail Rabbit	*Sylvilagus floridanus*
E. Fox Squirrel	*Sciurus niger*
E. Gray Squirrel	*Sciurus carolinensis*
Red Fox	*Vulpes fulva*
Gray Fox	*Urocyon cinereoargenteus*
Raccoon[a]	*Procyon lotor*
Opossum[a]	*Didelphis marsupialis*
Mink	*Mustela vison*
River Otter	*Lutra canadensis*
Least Weasel	*Mustela rixosa*
Shorttail Weasel	*Mustela erminea*
Longtail Weasel	*Mustela frenata*
Striped Skunk	*Mephitis mephitis*
Spotted Skunk	*Spilogale putorius*
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethica*
Ruffed Grouse	*Bonasa umbellus*
Sharp-tailed Grouse	*Pedioecetes phasianellus*
Bobwhite Quail	*Colinus virginianus*
Hungarian Partridge	*Perdix perdix*
Ring-necked Pheasant	*Phasianus colchicus*
Wild Turkey	*Meleagris gallopavo*
Mourning Dove	*Zenaidura macroura*
Rock Dove	*Columba livia*
Woodcock	*Philohela minor*
Common Snipe	*Capella gallinago*
King Rail	*Rallus elegans*
Virginia Rail	*Rallus limicola*
Sora Rail	*Porzana carolina*
Canada Goose	*Branta canadensis*
Snow Goose	*Chen hyperborea*
Blue Goose	*Chen caerulescens*
Mallard	*Anas platyrhynchos*
Black Duck	*Anas rubripes*
Gadwall	*Anas strepera*
Pintail	*Anas acuta*
Green-winged Teal	*Anas carolinensis*
Blue-winged Teal	*Anas discors*
American Widgeon	*Mareca americana*
Shoveler	*Spatula clypeata*
Wood Duck	*Aix sponsa*
Redhead	*Aythya americana*
Canvasback	*Aythya valisineria*
Lesser Scaup	*Aythya affinis*
Ring-necked Duck	*Aythya collaris*
Bufflehead	*Bucephala albeola*
Ruddy Duck	*Oxyura jamaicensis*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Hooded Merganser	*Lophodytes cucullatus*
Coot	*Fulica americana*
Common Gallinule	*Gallinula chloropus*

Table 14. Animals Common to the Diverse Zones of Vegetation from the River to the Blufftop (after Wallace, McHarg, Todd and Roberts, 1969)

Habitat Type	Species
Deep marshes	Frogs; water snakes, turtles; coot, grebes, rails, blackbirds, marsh birds, blue-winged teal, mallard, herons, black tern; muskrat, mink.
Shallow marshes	Frogs, toads, snakes and other amphibians and reptiles; coot, grebes, blue-winged teal, mallard (nesting), migrating ducks, pheasant; muskrat, mink, and white-tailed deer.
Wet meadows	Leopard frogs, salamanders, snakes, other amphibians and reptiles; herons, pheasant, nesting waterfowl, marsh song-birds; red fox, white-tailed deer.
Mud flats, sandy shores and bogs	Nesting ducks, other marsh and shore birds, songbirds; small mammals, deer.
Wooded and shrub swamps	Spring peeper, swamp tree frogs; woodcock, marsh and song birds, herons, wood duck (nesting); small rodents and shrews, beaver, mink, racoon, and deer.
River bottom forests	Green frog, salamanders; snakes, turtles; wood ducks, forest songbirds, upland gamebirds; cottontail rabbit, raccoon, gray fox, white-tailed deer.
Upland hardwoods	Wood frog, salamanders; snakes, including pilot black snake, red-bellied snake and Brocen snake; ruffed grouse; flying squirrel, raccoon, gray fox, red fox, white-tailed deer.
Dry oak savanna and dry uplands	Snakes; ruffed grouse, pheasant; spotted and striped skunks, red fox, woodchuck, white-tailed deer.
Brush prairie	Prairie songbirds including horned lark, bobolink, vesper sparrow, lark sparrow; killdeer.
Prairie grassland	Hog-nosed snake; upland plover, Hungarian partridge; whitetail jackrabbit, 13-lined and Franklin ground squirrels, badger.

Table 15. Bird Abundance in the River Valleys in the Twin Cities Area Based Upon Casual Observations, 1973 (Co[illegible]th, 197[illegible])

Bird Species	Flood Plain Lakes		SAF Pools	Pool 1	Pool 2	Minn. R	St. C[illegible]	Total [illegible]
	Minn. R.	Pool 2						
Great blue heron	75	29			13	84		2[illegible]
Common egret	19	86			8	4		117
American bittern	3							3
Mallard	25	25	90	1	5	20		166
Coot	48	6						54
Wood duck	9	15	18		2	17		61
Pheasant			1					1
Woodpecker			2			1		3
Yellow-shafted flicker			3					3
Grackle			2			1		3
Sparrow			1					1
White-throated sparrow			1					1
Spotted sandpiper			1			19		20
Bank swallow						3		3
Belted kingfisher		1			8	22		31
Black tern						3		3
Teal						2		2
Black duck						1		1
Hooded merganser						1		1
Pied-billed grebe			1					1
Barn swallow			1					1
Osprey		1				2		3
Red-tailed hawk	1							1
Green heron		1			2	38		[illegible]
Crow						12		1[illegible]
Black-crowned night heron					8			[illegible]
Common tern		12						12
Canada goose			10			7		17
Total No. individ./pool	180	176	130	1	47	237	0	771

the St. Anthony Falls pools because of the much reduced tree cover along the banks in these upstream pools.

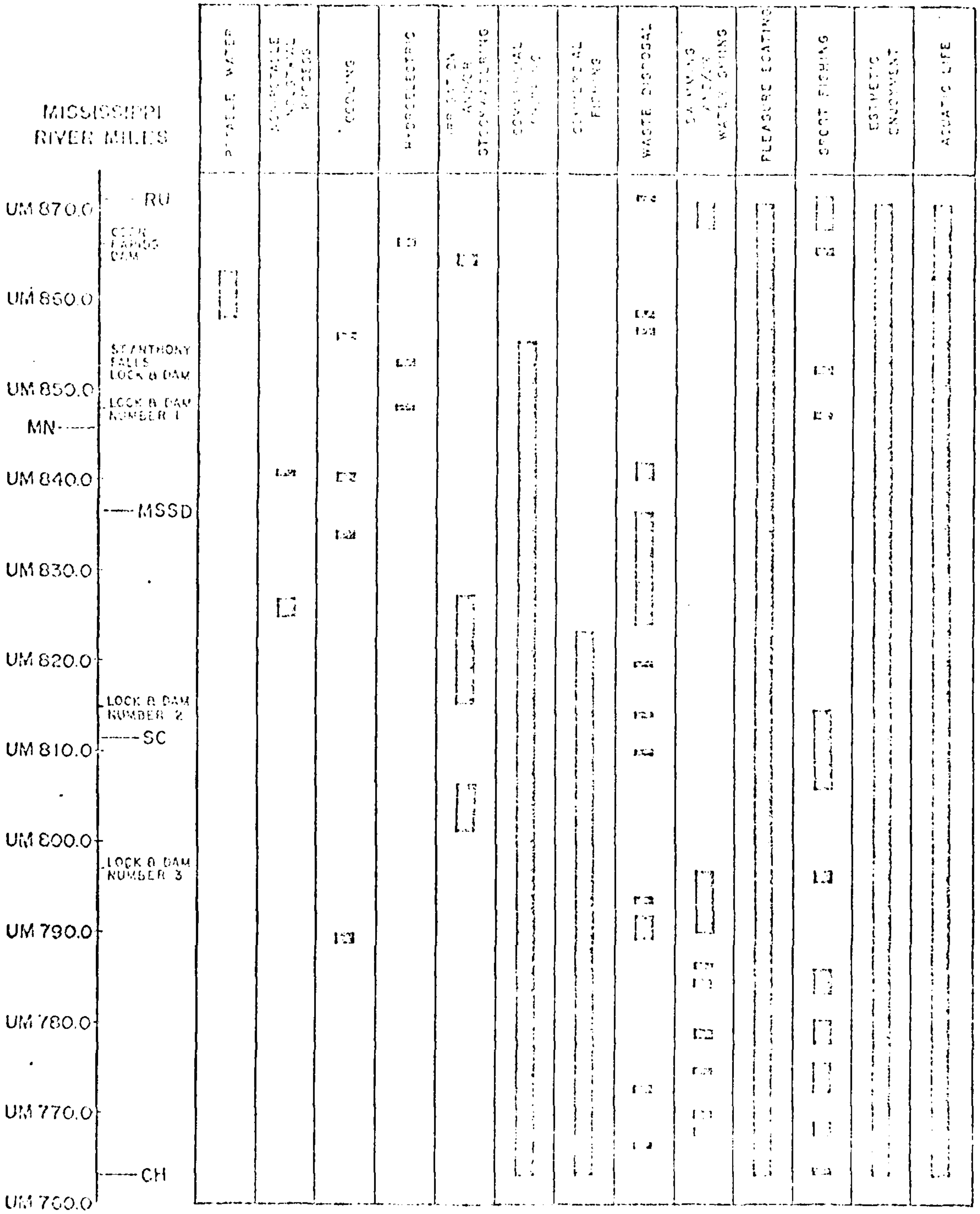
Herons may be seen flying over or roosting in the Lock and Dam 1 area. These are probably from two large rookeries at the downstream tip of Pig's Eye Island, opposite the St. Paul stockyards. The largest one is a 170-nest black-crowned night heron and common American egret rookery, sandwiched between a large barge fleeting basin on the west and a large barge terminal on the east. These waterfowl are quite sensitive to man's activities; for instance, they have been reported to abandon their rookery when highway construction approached within a mile (Partch, 1973).

Water Quality

Water use in Pool 1, as in adjacent pools, is varied, including supply for industry, navigation and recreation and aesthetic enjoyment by a large metropolitan area (See Figure 35).

Generally water quality is good in Pool 1 compared with downstream water quality, except for bacterial levels (FWPCA, 1966). During and just after rainfall some or all of numerous storm sewer discharges increase bacteria to levels which create a health hazard. However, water quality throughout Pool 1 permits a wider usage than in Pool 2, although in 1966 water quality exceeded the maximum level of pollutants for such uses as potable water and swimming and other water contact sports. In 1973, however, swimming was popular at several sites in Pool 1. One of the most popular sites was adjacent to the abandoned lock upstream from the Lake Street Bridge.

Daily records of some water quality parameters are available for mid-1967 to mid-1969 and serve to illustrate the seasonal variation of these parameters in the Mississippi River in the Twin Cities area. Some variation from these data may occur between Anoka and Pool 1 due to industrial storm sewer [illegible]. This may be especially true of the temperature downstream from [illegible] Power Plant.



LEGEND

RU	Rum River	CH	Chippewa River
MN	Minnesota River	MSSD	Minneapolis - St. Paul Sanitary District
SC	St. Croix River		

Figure 35. Present Water Uses of the Mississippi River in the Twin Cities Metropolitan Area (FWPCA, 1966)

Daily flow which is recorded at Anoka (and at St. Paul) by the U. S. Geological Survey, ranged between 2000 cfs and 25,000 cfs (Figure 2 in Appendix A, IV). At St. Anthony Falls the lowest flow was 462 cfs, in 1932 and the maximum was 91,000 cfs, in 1965.

Water temperature, dissolved oxygen (DO), pH and specific conductivity are automatically monitored by EPA at the Riverside Power Plant. The data from mid-1967 to mid-1969 illustrates the seasonal variation in these parameters. Water temperature ranged from a winter low of about 32°F to a summer high of 85°F (Figure 3 in Appendix A, IV). Dissolved oxygen ranged from a low of about 5 mg/l (milligrams per liter) in summer to a high of about 17 mg/l in winter. Generally the DO has two periods of low concentration: during low flows in summer and under the ice in winter (Figure 4 in Appendix A, IV). By comparison the DO record at Grey Cloud Island for the same period shows that the DO concentration may reach zero mg/l (Figure 5 in Appendix A, IV). Day to day variation also is greater within the Twin Cities.

Specific conductivity and pH occasionally show marked fluctuations, but no marked seasonal pattern. pH ranged from 6.5 to 8.5 (Figure 6 in Appendix A, IV). Specific conductance ranged from 200 to 450 micromhos (Figure 7 in Appendix A, IV).

Additional water quality data is recorded at the Minneapolis Water Works in Fridley. The 1973 data (through August) is included at Table 3 in Appendix A, IV.

Downstream from Pool 1 the water quality decreases considerably due to the turbidity and bacteria brought by the Minnesota River, and to treated sewage and industrial effluents; the sewage comes from 16 plants, the largest of which is the Metropolitan Wastewater Treatment Plant.

At the base of Lock and Dam 1 the turbulance increases the dissolved oxygen content of the river, apparently causing fish and waterfowl to congregate. Sport fishing is popular below the dam. And, as many as six black-crowned night herons have been attracted to the area.

The main water quality problem below Pool 1 comes from the discharge of the Metropolitan Wastewater Treatment Plant, the South St. Paul Sewage Plant as well as 16 other sources enter Pool 2 from the MWTP site downstream to Lock and Dam 2. These decrease the dissolved oxygen (DO), benthic organisms, and percent of game fish in the total fish population. At the same time, undesirable characteristics increase, such as coliform bacteria and pathogens (See Figure 36) 1973 data is in Tables 5 and 6 in Appendix A IV.

Aquatic Vegetation

The Twin Cities area riverine aquatic vegetation may be grouped into habitat types, such as deep and shallow marshes (greater and less than three feet deep respectively) and wood and shrub swamps (See Table 16). However, such habitats are not found in Pool 1 due to the deep gorge and to extensive development in the upper reach of the former floodplain. No aquatic vegetation is known to occur in the main channel. Apparently, no studies were made of the aquatic vegetation in Pool 1 prior to the construction of the Ford Dam in 1917.

Table 16. Aquatic Vegetation in the Mississippi River in the Vicinity of the Twin Cities (Wallace, *et al.*, 1969).

Habitat	Species
Deep Marshes	Cattail, bulrush, reed grass, round-stemmed bulrush, and wild rice. In open areas: pond weed, coontail, water milfoil, waterweeds, duckweed, white water lily, spatterdock and other aquatics.
Shallow Marshes	Grasses, bulrushes, spikerush, cattail, arrowhead, pickerelweed, smartweed, reed grass, whitetop, rice cut-grass, sedge and giant bur reed, and wet willow growths.
Wood and Shrub Swamps	Undergrowth: moss, duckweed, smartweed, and others.

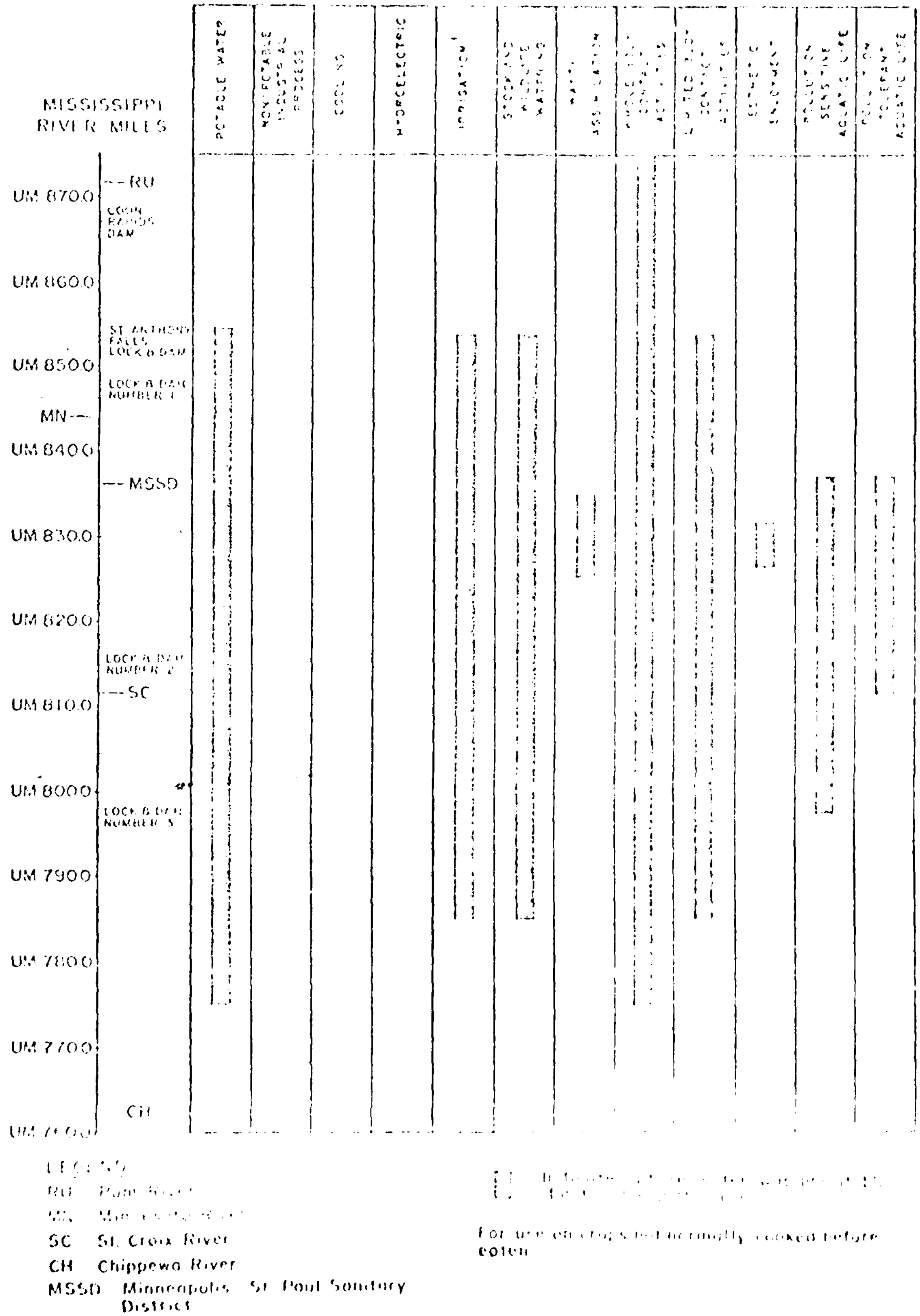


Figure 36. Water Uses Affected by Water Quality in the Mississippi River in the Twin Cities Metropolitan Area (TWPCA, 1966)

Aquatic Animals. More than 120 species of fish are found in the upper Mississippi River Basin (See Table 17). Sixteen of these species are recorded from Coon Rapids and 48 have been recorded in Pool 2. Of these species the smallmouth bass, northern redhorse, sheepshead and carp have been reported in Pool 1, although the information is incomplete (See Tables 18 and 19). No commercial fishing has been done in Pool 1. Sport fishing is light (Cunningham, 1973), although a recent article reported good smallmouth bass fishing (Hennessey, 1973).

Besides painted turtles, no other aquatic animals have been sighted, although the few shallow areas probably may have amphibians.

Bottom sediments grade in Pool 1 from rock and coarse sand, near St. Anthony Falls Lower Lock and Dam, downstream to fine sand and anaerobic silt (See Figures 37, 38 and 39). Farther downstream the organic content of the bottom sediment continues to increase (See Figure 40).

Benthic macroinvertebrates* show a downstream trend of increasing numbers of individuals but decreasing variety (kinds or species) per square foot (See Table 20). The increase downstream in Pool 1 in numbers of Chironomidae and Oligochaete agrees with the increase in organic content and the decrease in sediment particle size, which also agrees with the observed decrease downstream in the inner current.

There have been two previous studies of the benthic macroinvertebrates in the Mississippi River in the Twin Cities area. Dawley (1947) reported on clam collections made by herself and previous scientists since 1864. Her study shows that the number of clam species doubled between Anoka (Mile 866, 8 miles upstream from Transect UAA) and Nininger (Mile 817.6, between Transects 2YY and 2CC) (See Table 21). The comparatively lower density of clam species in 1973 is probably due to the lesser sampling effort than in Dawley's work, and to the significant decrease in water quality and current (due to Lock and Dam 1) in the Mississippi River since 1864.

*Bottom-dwelling organisms lacking backbones and visible to the naked eye.

Table 17

Checklist of Fishes Found in the Upper Mississippi River Basin (FWS, 1970)

Petromyzontidae – lampreys
  Chestnut lamprey *Ichthyomyzon castaneus* Girard
  Silver lamprey *Ichthyomyzon unicuspis* Hubbs and Trautman
Acipenseridae – sturgeons
  Lake sturgeon *Acipenser fulvescens* Rafinesque
  Pallid sturgeon [illegible] (Forbes and Richardson)
  ✓Shovelnose sturgeon [illegible] (Rafinesque)
Polyodontidae – [illegible]
  ✓ Paddlefish [illegible]
Lepisosteidae – [illegible]
  Spotted gar [illegible]
X Longnose gar [illegible]
  ✓Shortnose gar [illegible] Rafinesque
Amiidae – bowfin
  ✓Bowfin [illegible]
Clupeidae – herrings
  C Skipjack [illegible] (Rafinesque)
  C Ohio shad [illegible]
  × ✓Gizzard shad [illegible] (LeSueur)
  Threadfin shad [illegible] (Günther)
Salmonidae – [illegible]
  Cisco or [illegible] LeSueur
  Rainbow [illegible]
Hiodontidae – [illegible]
  Goldeye [illegible] (Rafinesque)
  ✓Mooneye [illegible]
Umbridae – [illegible]
  Central [illegible] (Kirtland)
Esocidae – pike
  Grass pickerel [illegible] LeSueur
× × ✓Northern [illegible]
  Muskellunge [illegible] Mitchill
Cyprinidae – [illegible]
  Stoneroller [illegible] (Rafinesque)
  Southern [illegible] erythrogaster (Rafinesque)
× × ✓Carp *Cyprinus* [illegible]
  × Creek [illegible] (Girard)
  Silverjaw [illegible]
  Brassy [illegible] Hubbs
  Cypress [illegible]
  Silvery [illegible] Agassiz
  Northern [illegible] Girard
  Speckled chub [illegible]
  Flathead chub [illegible]

  Sicklefin chub *Hybopsis meeki* Jordan and Evermann
  × Silver chub *Hybopsis storeriana* (Kirtland)
  Gravel chub *Hybopsis x-punctata* Hubbs and Crowe
– × Golden shiner *Notemigonus crysoleucas* (Mitchill)
  Pallid shiner *Notropis amnis* Hubbs and Greene
  Pugnose shiner *Notropis anogenus* Forbes
  × Emerald shiner *Notropis atherinoides* Rafinesque
× – River shiner *Notropis blennius* (Girard)
  Ghost shiner *Notropis buchanani* Meek
  Central common shiner *Notropis cornutus chrysocephalus* (Rafinesque)
× × Common shiner *Notropis cornutus* (Mitchill)
× – Bigmouth shiner *Notropis dorsalis* (Agassiz)
× × Spottail shiner *Notropis hudsonius* (Clinton)
  Red shiner *Notropis lutrensis* (Baird and Girard)
  Rosyface shiner *Notropis rubellus* (Agassiz)
  Silverband shiner *Notropis shumardi*
× × Spotfin shiner *Notropis spilopterus* (Cope)
  × Sand shiner *Notropis stramineus* (Cope)
  Weed shiner *Notropis texanus* (Girard)
  Blacktail shiner *Notropis venustus* (Girard)
  Mimic shiner *Notropis volucellus* (Cope)
  Channel mimic shiner *Notropis volucellus wickliffi* Trautman
  Pugnose minnow *Opsopoeodus emiliae* Hay
  Suckermouth minnow *Phenacobius mirabilis* (Girard)
× × Bluntnose minnow *Pimephales notatus* (Rafinesque)
× × Fathead minnow *Pimephales promelas* Rafinesque
× – Bullhead minnow *Pimephales vigilax* (Baird and Girard)
  Longnose dace *Rhinichthys cataractae* (Valenciennes)
  Creek chub *Semotilus atromaculatus* (Mitchill)
Catostomidae – suckers
  River carpsucker *Carpiodes carpio* (Rafinesque)
  Quillback *Carpiodes cyprinus* (LeSueur)
  Highfin carpsucker *Carpiodes velifer* (Rafinesque)
× × White sucker *Catostomus commersoni* (Lacepede)
  C Blue sucker *Cycleptus elongatus* (LeSueur)
  Northern hog sucker *Hypentelium nigricans* (LeSueur)
  × Smallmouth buffalo *Ictiobus bubalus* (Rafinesque)
× ✓Bigmouth buffalo *Ictiobus cyprinellus* (Valenciennes)
  Black buffalo *Ictiobus niger* (Rafinesque)
  Spotted sucker *Minytrema melanops* (Rafinesque)
× × Silver redhorse *Moxostoma anisurum* (Rafinesque)
  Golden redhorse *Moxostoma erythrurum* (Rafinesque)
× × ✓Northern redhorse *Moxostoma macrolepidotum* (LeSueur)
  Greater redhorse *Moxostoma valenciennesi* Jordan

Ictaluridae – freshwater catfishes
- ✓ Blue catfish *Ictalurus furcatus* (LeSueur)
- ✓ Black [illegible] *Ictalurus melas* (Rafinesque)
- ✓ Yellow [illegible] *[illegible]* (LeSueur)
- ✓ Brown [illegible] (LeSueur)
- x ✓ Chan[illegible] *[illegible] punctatus* (Rafinesque)
- Ston[illegible] *Noturus* [illegible]
- x x Tadp[illegible] *Noturus gyrinus* (Mitchill)
- ✓ Flat[illegible] (Rafinesque)

xx (bracketing Black, Yellow and Brown)

Anguillidae – [illegible]
- ✓ Am[illegible] *[illegible] rostrata* (LeSueur)

Cyprinodont[illegible]
- Bl[illegible] *Fundulus notatus* (Rafinesque)

Poeciliidae – [illegible]
- Mos[illegible] *[illegible] affinis* (Baird and Girard)

Gadidae – [illegible]
- [illegible]

Gasterost[illegible]
- x Bro[illegible] *[illegible] inconstans* (Kirtland)

Percopsidae – [illegible]
- x x Tro[illegible] *[illegible] omiscomaycus* (Walbaum)

Aphredoder[illegible]
- Pirate [illegible] *Aphredoderus sayanus* (Gilliams)

Serranidae – [illegible]
- x Wh[illegible] (Rafinesque)
- Ye[illegible] *[illegible]* (Jordan and Eigenmann)

Centrarch[illegible]
- x ✓ Rock [illegible] *[illegible] rupestris* (Rafinesque)
- Warm[illegible] *Chaenobryttus gulosus* (Cuvier)
- x x ✓ Gree[illegible] *[illegible] cyanellus* Rafinesque
- x x Pumpkinseed *Lepomis gibbosus* Rafinesque
- x Orangespotted sunfish *Lepomis humilis* (Girard)
- x x ✓ Bluegill *Lepomis macrochirus* Rafinesque
- Longear sunfish *Lepomis megalotis* (Rafinesque)
- Redear sunfish *Lepomis microlophus* (Günther)
- x x Smallmouth bass *Micropterus dolomieui* Lacepède
- x ✓ Largemouth bass *Micropterus salmoides* (Lacepède)
- White crappie *Pomoxis annularis* Rafinesque
- x x ✓ Black crappie *Pomoxis nigromaculatus* (LeSueur)

Percidae – perches
- Crystal darter *Ammocrypta asprella* (Jordan)
- Western sand darter *Ammocrypta clara* Jordan and Meek
- Mud darter *Etheostoma asprigene* (Forbes)
- Rainbow darter *Etheostoma caeruleum* Storer
- Bluntnose darter *Etheostoma chlorosomum* (Hay)
- Iowa darter *Etheostoma exile* (Girard)
- Fantail darter *Etheostoma flabellare* Rafinesque
- x x Johnny darter *Etheostoma nigrum* Rafinesque
- Banded darter *Etheostoma zonale* (Cope)
- x x ✓ Yellow perch *Perca flavescens* (Mitchill)
- x x Logperch *Percina caprodes* (Rafinesque)
- Blackside darter *Percina maculata* (Girard)
- Slenderhead darter *Percina phoxocephala* (Nelson)
- x River darter *Percina shumardi* (Girard)
- x ✓ [illegible] *Stizostedion canadense* (Smith)
- x x ✓ Walleye *Stizostedion vitreum vitreum* (Mitchill)

Sciaenidae – drums
- Freshwater drum *Aplodinotus grunniens* Rafinesque

Atherinidae – silversides
- x Brook silverside *Labidesthes sicculus* (Cope)

Table 18. Common Species of Game Fish in the Large Rivers of the Twin Cities Metropolitan Area (FWPCA, 1966).

Species	Mississippi River: Rum River To St. Anth. Falls	Pool No. 1	Pool No. 2	Pool No. 3	Minnesota River: River Mile 70 to 25	River Mile 25 to 0	St. Croix River
Walleyed Pike	X	(list is incomplete)	X	X	X		X
Sauger			X	X	X		X
Northern Pike	X		X	X	X		X
Black Crappie	X		X	X	X	X	X
White Crappie				X	X	X	
Largemouth Bass			X		X		
Smallmouth Bass	X	X			X		X
Rock Bass	X		X				X
White Bass				X	X		X
Bluegill	X		X	X			X
Channel Catfish			X	X	X	X	X
Sturgeon							X
Flathead Catfish				X	X	X	X
Green Sunfish			X				
Pumpkinseed	X						X
Brown Trout							X
Number of Species	7	-	9	9	10	4	13

Note: This is not necessarily a complete list.

Table 19. Common Species of Rough Fish in the Large Rivers of the Twin Cities Metropolitan Area (FWPCA, 1966).

	Mississippi River				Minnesota River		
	Rum River to St. Anthony Falls	Pool No. 1	Pool No. 2	Pool No. 3	River Mile 70 to 25	River Mile 25 to 0	St. Croix River
Carp	X	X	X	X	X	X	X
Quillback					X		X
Sheepshead		X	X	X		X	X
Brown Bullhead							X
Bigmouth Buffalofish	X		X	X	X	X	X
Northern Carpsucker				X	X	X	
Northern Redhorse	X	X	X	X	X		X
Longnose Gar				X			X
Shortnose Gar			X	X	X	X	X
Bowfin		(list is incomplete)	X				
Mooneye			X	X			X
Gizzard Shad			X	X	X	X	
Common Sucker	X		X	X	X	X	X
Spotted Sucker							
Yellow Bullhead	X						
Black Bullhead	X						
Golden Shiner				X			
Perch			X				X
River Sucker			X				
Number of Species	6	--	11	11	8	7	11

Note: This is not necessarily a complete list.

Profiles Drawn Looking Downstream (South)

Bottom type: mu = mud, sa = sand, de = debris, gr = gravel or rocks.
[]= sample plot (quadrat), + = plotless tree sample (point quarter),
≡= top of bank, b = bottom sampled

Figure 37.

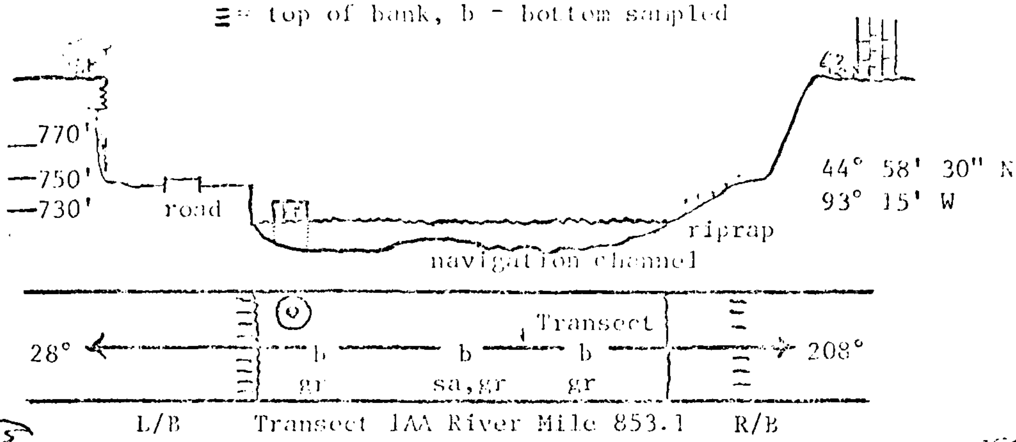


Figure 38.

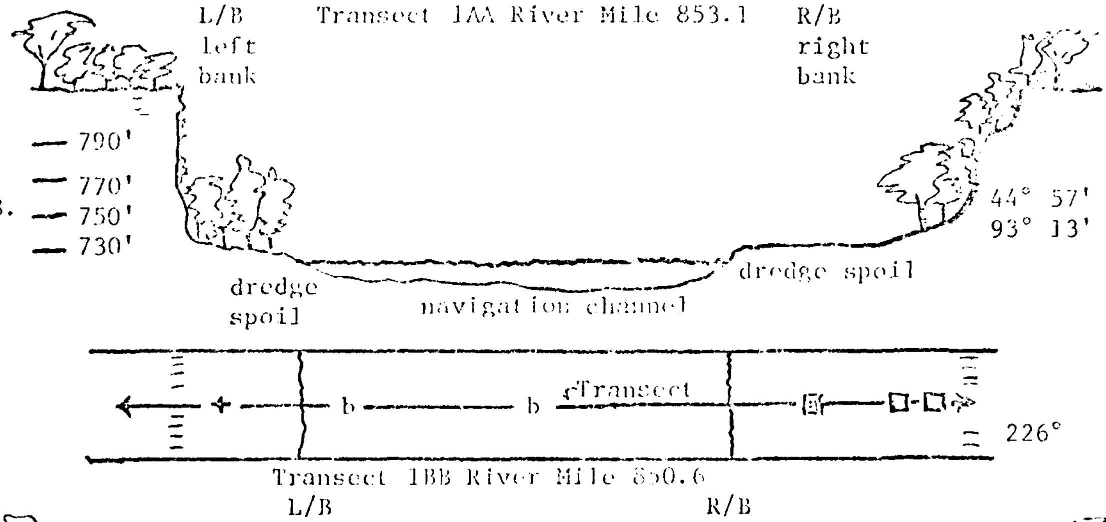
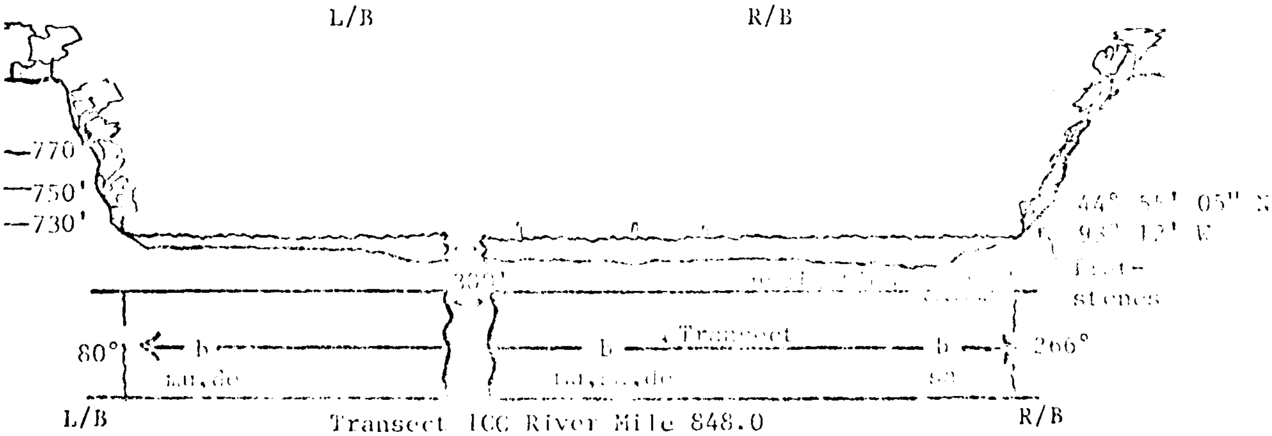


Figure
39.



SCALE: 1' = 100"

Schematic Diagrams of Riverscape Profiles, Plant and
Animal Sampling Locations, and Bottom Types at Each
Standard Transect in Pool 1 (Gudmundson, 1973)

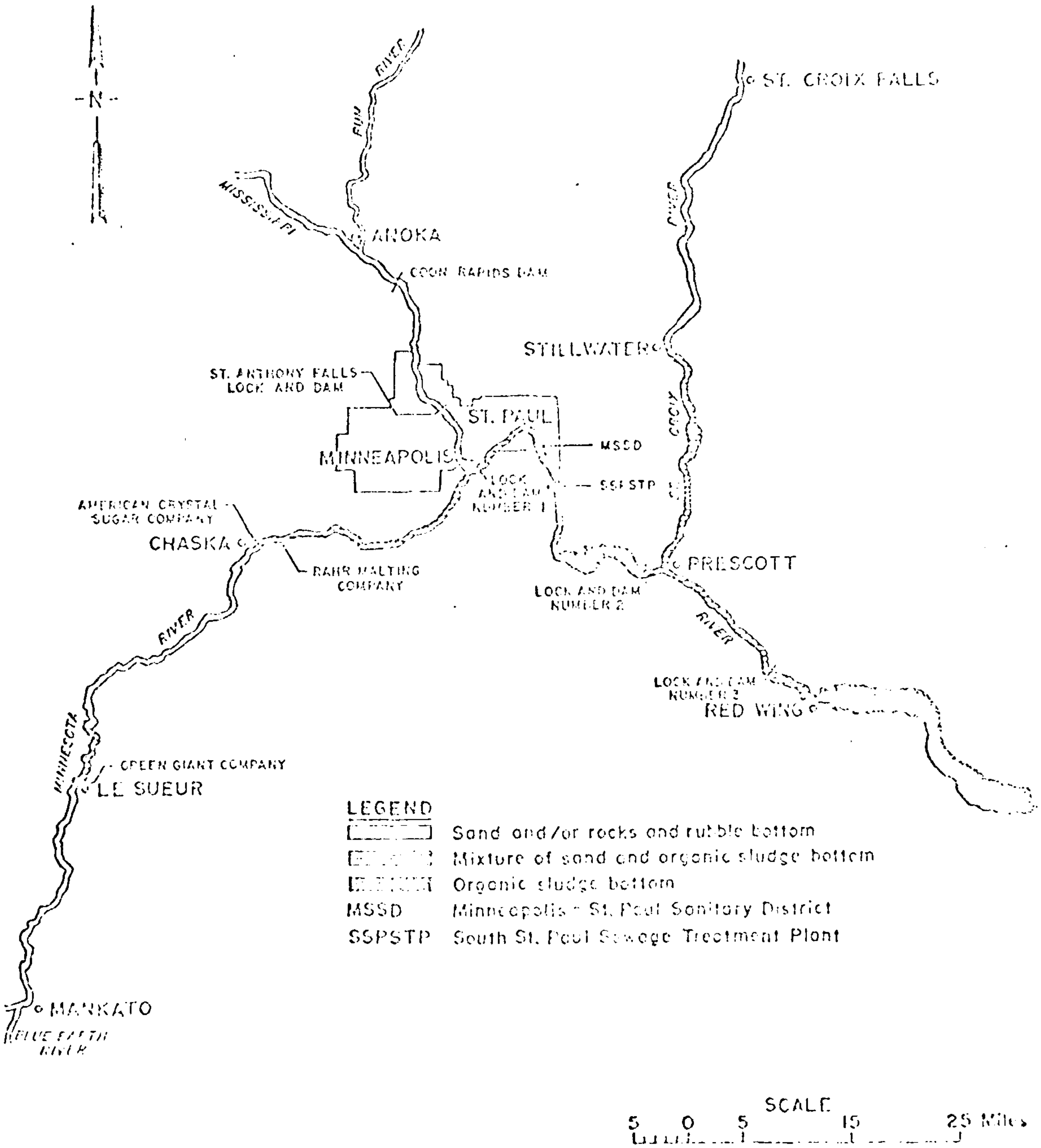


Figure 40. Distribution of Bottom Sediments (FWPCA, 1966)

Table 20. Average Abundance (per square foot) of Benthic Macroinvertebrates in the Mississippi River in the Twin Cities Area in 1973

TAXA		Abundance of Benthic Organisms											
		St. Anthony Falls				Pool 1				Pool 2			
	Bottom Type	Rocks &Sand	Rocks &Sand	Gravel &Sand	Gravel &Silt	Rocks to Sand	Sand& Gravel	Rocks &Sand	Sand &Silt	Rocks& Gravel	Sludge &Sand	Mud& Sand	Sludge
	Transect	UAA	UBB	UCC	LBB	1AA	1XX	1BB	1CC	2AA	2BB	2XX	2CC
INSECTA													
Diptera:	Chironomidae	16	2	3	10	5	4	3	15	2	9	7	5
	Empididae	2											
	Simuliidae	3											
	Chaoboridae										1		
Trichoptera:	Hydropsychidae	30	7	1	6	6		1		5			
	Psychomyiidae				1					1			
Ephemeriptera:	Potamanthidae	1				1				1			
	Caenidae	3											
Coleoptera	Elmidae	8	1	2	1	1							
Plecoptera:	Perlidae	1											
	Chloroperlidae	1											
PELECYPODA							1						
HIRUDINEA										1			
OLIGOCHAETA													
	Tubificidae							4				11	
	Unknown				3			1	6		14	16	35
No. Taxa/ft^2		9	3	3	5	4	2	4	2	5	3	3	2
No. individuals/ft^2		65	10	6	21	13	5	9	21	9	24	34	40

Note: data averaged from Table in Appendix A, IV.

Table 21. Distribution of Clams in the Mississippi River in the Twin Cities Area (from Dawley, 1947)

		*	+	
Fusconaia ebenus				X
Fusconaia flava				X
Megalonaias gigantea				X
Amblema plicata				X
Amblema costata				X
Quadrula quadrula			X	X
Quadrula pustulosa			X	X
Quadrula metanevra			X	X
Tritogonia verrucosa			X	X
Cyclonaias tuberculata				X
Plethobasus cyphyus				X
Elliptio dilatata			X	X
Elliptio crassidens				X
Lasmigona complanata				
Lasmigona costata				X
Lasmigona compressa [illegible]				X
Anodonta grandis				X
Anodonta [illegible]				X
Anodonta corpulenta				X
[illegible]		X		
Alasmidonta marginata truncata				X
Arcidens confragosus				X
Strophitus rugosus				X
Obliquaria reflexa				X
Obovaria olivaria				X
Actinonaias carinata		X	X	X
Truncilla truncata			X	X
Truncilla donaciformis				X
Plagiola lineolata			X	X
Leptodea fragilis				X
Proptera alata megaptera			X	
Proptera laevissima				X
Ligumia recta latissima	X	X		
Lampsilis [illegible]				X
Lampsilis [illegible]		X		X
Lampsilis [illegible]	X	X		
Lampsilis [illegible]				X
No. species:	5	5	10	35

* below Minneapolis

\+ Nininger is located between transects 2YY and 2CC of the present study.

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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0059

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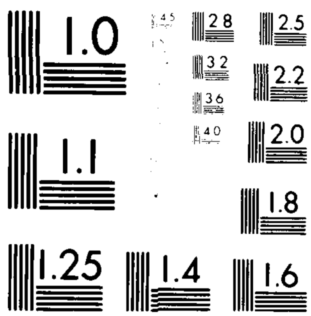


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

In a 1964 study by Hokanson (1968) benthic animal communities were collected at Coon Rapids (Mile 866 above St. Anthony Falls) and on the present 2YY transect (Mile 821.3, Pool 2). A comparison of the 1964 data with that of 1973 shows a decrease in diversity and abundance upstream from the Twin Cities and in the sandy bottom (mid-channel) downstream from the Twin Cities (See Table 22). In the muddy bottom downstream from the Twin Cities (Spring Lake bottom) diversity remained the same but abundance doubled.

Threatened Species

Several lists of threatened (or rare and endangered) plants and animals have been compiled. No threatened species were found in Pool 1 during the present study and none have been reported previously. A more detailed survey is warranted, especially for prairie species in the prairie remnant in the Mississippi Park (between West River Boulevard and the brim of the bluff) at 36th Avenue.

These lists of threatened species include species protected legally and/or other non-protected species whose populations are known to be or are suspected of being dangerously low, either locally or nationally. Species rare locally but not in adjacent states, i.e. species at the limit of their geographic range, are included in some lists. This inclusion serves to encourage maintenance of a broad genetic (breeding) pool to help insure survival of the whole species population. The inclusion of these species also serves to encourage the maintenance of a broad diversity of plants and animals for Minnesotans to enjoy.

The variety of lists of threatened species is due to two difficulties which are encountered in compiling such a list. The first difficulty is the definition of a threatened species, i.e. at what population size and survival rate (birth rate versus death rate) does a species population become in danger of extinction. Secondly, there is a lack of specific information on the current population size and breeding success of many species.

Table 22. Comparison of Hokanson Summer 1964 Data with Summer 1973 Data of Average Number of Benthic Animals (Macroinvertebrates) Per Square Foot at Two Stations on the Mississippi River (Hokanson, 1968; Colingsworth and Gudmundson, 1973)

CLASS Family	Upstream from Twin Cities, Coon Rapids, Mile 866 and Camden (Transect UAA) Mile 857		Downstream from Twin Cities Spring Lake Mile 821 (Transect 2YY)			
			Muddy Bottom		Sandy Bottom	
	1964	1973	1964	1973	1964	1973
INSECTA						
Diptera: Ceratopogonidae					0	
Chironomidae	80	16	6	5	148	11
Empididae		2				
Simuliidae		3				
Tipulidae		0				
Trichoptera: Hydropsychidae		30				
Psychomyiidae	8					
Coleoptera: Elmidae	2	8				
Ephemeroptera: Baetidae	1				0	
Caenidae	6	3			0	
Ephemeridae	1	0				
Heptageniidae	12	0				
Leptophlebiidae	1					
Potamanthidae	6	1				
Plecoptera: Perlidae		1				
CRUSTACEA						
Asellidae					2	
OLIGOCHAETA	11		10	30	55	
HIRUDINEA						
Glossiphoniidae	1				2	
GASTROPODA						
Ancylidae	4				0	
TURBELLARIA	4					
No. Taxa/ft^2	13	8	2	2	4	2
No. Individuals/ft^2	137	64	16	35	207	34

Plants. A list of rare and endangered plants in Minnesota was compiled by the Minnesota Department of Natural Resources (MN DNR, 1971). This list contains a total of ten plant species, including five plants found in moist prairies, three plants found in open hardwoods, and two plants found in the northern conifer forests (See Table 23).

Morley (1972) compiled an extensive list of threatened plant species in several categories. His list of plants legally protected in Minnesota includes all species of the orchid family; all species of lily, trillium and gentian; and trailing arbutus (See Table 24).

A second category in Morley's list included those plants rare in Minnesota and all of North America: a total of four plants. One of these species, the Minnesota trout-lily or adder's tongue, is found nowhere else but in Minnesota.

Morley included a third category containing 252 plants which are rare in Minnesota but are more or less abundant in adjacent regions. A total of 36 of these species are found in one or more of the following metropolitan counties: Hennepin, Ramsey, Washington, Dakota and Scott (Table 25).

Morley's fourth category includes those plants typical of our native grasslands. This list includes 122 plant species. The native grassland habitation is the "most poorly represented [in the University Herbarium] and in greatest danger of eradication in the state." A more detailed study is urgently needed to determine if the drier portions of the spoil banks do harbor these threatened plants, or, if not, then to determine the potential of the spoil sites to provide a refuge for native grassland plants.

Barthelemy (1971) includes three plant species in his list: two cacti and a legume (See Table 26).

Animals. Barthelemy's (1971) list includes thirty-six rare and endangered animals, including three reptiles and amphibians, one mammal and 29

Table 23. Rare and Endangered Plants of Minnesota (MNDNR, 1971)

	<u>Moist Prairie Habitat</u>
Moist meadows	Wild orange-red lily, wood lily, <u>Lilium philadelphicum</u>
	Shooting star, <u>Dodecatheon meadia</u>
	Small white lady's-slipper, <u>Cypripedium candidum</u> (orchid)
	Prairie phlox, <u>Phlox pilosa</u>
	Blue-eyed grass, <u>Sisyrinchium angustifolium</u>
	<u>Grazing in Hardwoods in the Southeast</u>
Fairly open hardwoods	Bluebell, Virginia cowslip or Lungwort, <u>Mertensia virginica</u>
	*Minnesota trout-lily, <u>Erythronium propullans</u>
	*Adam-and-Eve root, <u>Aplectrum hyemale</u> (orchid)
	<u>Northern Forest</u>
Fairly open coniferous forests	Yew, <u>Taxus canadensis</u>
	Ram's-head lady's-slipper, <u>Cypripedium arietinum</u> (orchid)

*has always been fairly rare

Table 24. Rare and Endangered Plants of Minnesota with the Counties in Which They Have Been Found (Nature Conservancy - Morley, 1972)

Plants rare in Minnesota and in all of North America

Cruciferae; Mustard Family
Draba norvegica, Whitlow-grass: Cook.

Leguminosae; Pea Family
Lespedeza leptostachya, Prairie Bush-clover: Cottonwood, Crow Wing, Goodhue.

Liliaceae; Lily Family
Erythronium propullans, Dwarf or Minnesota Trout-lily or Adder's Tongue: Goodhue, Rice. Found nowhere else in the world.

Orchidaceae; Orchid Family
Malazis paludosa, Bog Adder's Mouth: Clearwater, Ottertail.

Plants legally protected in Minnesota (the protection is weak, and needs strengthening).

Ericaceae; Heath Family
Epigaea repens, Trailing Arbutus.

Gentianaceae; Gentian Family
Gentiana, Gentian, all species.

Liliaceae; Lily Family
Lilium, Lily, all species
Trillium, trillium, all species.

Nymphaeaceae; Water Lily Family
Nelumbo lutea, Lotus Lily.

Orchidaceae; Orchid Family
All Species.

Table 25. Plants Rare in Minnesota but More or Less Abundant in Adjacent Regions (Morley, 1972).

PLANTS	FOUND IN (COUNTY)
Angiosperms; Flowering Plants	
Alismataceae; Water Plantain family	
Sagittaria graminea, grass-leaved arrowhead	Ramsey, Washington, St. Louis
Araceae; Arum family	
Arisaema dracontium, Green dragon, dragon root	Dakota, Winona, Houston
Araliaceae; Ginseng family	
Panax quinquefolius, ginseng	Once widespread from Houston to Jackson to Mille Lacs to Washington Counties, now nearly exterminated by herb-hunters
Campanulaceae; Bluebell family	
Specularia leptocarpa, western Venus' looking-glass	Ramsey
Caryophyllaceae; Cactus family	
Stellaria alsine, chickweed	Ramsey, Winona
Cistaceae; Rock-rose family	
Helianthemum canadense, frostweed	Fillmore, Houston, Winona, Washington
Compositae; Sunflower family	
Coreopsis tinctoria, golden coreopsis	Blue Earth, Hennepin, Ramsey
Convolvulaceae; Morning-glory family	
Cuscuta polygonorum, smartweed dodder	Freeborn, Hennepin
Cruciferae; Mustard family	
Arabis laevigata, smooth rock cress	Clearwater, Todd, Hennepin, Houston
Cyperaceae; Sedge family	
Carex formosa	Ramsey
Carex plantaginea	Hennepin, Winona
Scleria triglomerata, tall nut-rush	Anoka, Hennepin, Ramsey
Scleria verticillata, low nut-rush	Blue Earth, Dakota, Hennepin, Scott
Droseraceae; Sundew family	
Drosera linearis, slender-leaved sundew	Hennepin
Gramineae; Grass family	
Echinochloa walteri, cockspur grass	Wabasha, Washington
Juncaceae; Rush family	
Juncus articulatus, jointed rush	Ramsey

Table 25 (Continued).

PLANTS	FOUND IN (COUNTY)
Angiosperms; Flowering Plants	
Leguminosae; Pea family	
Astragalus ceramicus, rattle-pod	Ramsey
Lythraceae; Loosestrife family	
Decodon verticillatus, swamp loosestrife	Anoka, Chisago, Hennepin
Najadaceae; Naiad family	
Najas olivacea, bright-green naiad	Anoka, Ramsey
Onagraceae; Evening primrose family	
Gaura biennis, biennial gaura	Hennepin Houston
Potamogetonaceae; Pondweed family	
Potamogeton diversifolius, Rafinesque's pondweed	Anoka, Ramsey
Rosaceae; Rose family	
Rubus foliofiorus, blackberry	Ramsey, Washington, St. Louis
Rubus latifoliolus, blackberry	Isanti, Ramsey
Rubus rosendahlii, Rosendahl's blackberry	Ramsey
Rubus semisetosus, blackberry	Anoka, Ramsey
Rubiaceae; Madder family	
Galium verum, yellow bedstraw	Hennepin, Lac Qui Parle, St. Louis
Scrophulariaceae; Figwort family	
Aureolaria pedicularia, false foxglove	Hennepin, Washington, Houston
Besseya bullii, besseya	Dakota, Goodhue, Hennepin, Ramsey, Scott, Washington
Gerardia auriculata, auricled gerardia	Blue Earth, Dakota, Nicollet
Gerardia gattingeri, Gattinger's gerardia	Nicollet, Wabasha, Winona, Washington
Gerardia purpurea, large purple gerardia	Hennepin
Solanaceae; Potato family	
Solanum triflorum, cut-leaved nightshade	Clay, Hennepin
Umbelliferae; Parsley family	
Hydrocotyle americana, American marsh pennywort	Chisago, Washington, Houston
Verbenaceae; Vervain family	
Verbena simplex, narrow-leaved vervain	Fillmore, Rock, Scott
Xyridaceae; Yellow-eyed grass family	
Xyris torta, slender yellow-eyed grass	Anoka, Hennepin

Table 26. Rare and Endangered Plants, Amphibians, Reptiles Birds and Mammals in Minnesota (Barthelemy, 1971)

Plants

Lotus americana, birdsfoot-trefoil
Mammilaria vivipara, cactus
Opuntia humifusa, prickly pear cactus

Amphibians

Cricket frog
Red-backed salamander
Common newt

Reptiles

Blue-tailed skink
Wood turtle
Blanding's turtle

Birds

Sprague's pipit
Baird's sparrow
Yellow rail
White pelican
Egrets: 1. Common (American)
2. Cattle
3. Snowy

Birds (Continued)

Trumpeter swan
Bald eagle
Osprey
Peregrine falcon
Marsh hawk
Sandhill crane
Piping plover
Wilson's phalarope
Avocet
Western willet
Caspian tern
Great gray owl
Hawk owl
Boreal chickadee
Chestnut-collared longspur
Lark sparrow
Sharp-tailed sparrow
Le Conte's sparrow
Grasshopper sparrow
Henslow's sparrow
Yellow-breasted chat
Prothonotary warbler

Mammals

Star-nosed mole

birds. Of these the sandhill crane, osprey and American (common) egret occur in the Twin Cities area.

The list of rare and endangered species compiled by the U. S. Fish and Wildlife Service (1970) includes two mammals, four birds and one fish (Table 27). Although Pool 1 is within the geographic range or migration of these species, none are likely to occur in Pool 1 due to lack of habitat.

Pre-project Environment

A few old photographs and several studies suggest the nature of the habitat in Pool 1 prior to the nine-foot channel project.

A view downstream taken in the 1890's from the Upper St. Anthony Falls Dam shows a narrow, rapid Mississippi River littered with logs of the lumbering industry (Figure 41). The exposed floodplain on the right bank is particularly littered with lumber, shacks and construction. In the foreground is the Stone Arch Bridge and farther downstream the (now absent) 10th Avenue Bridge. Buildings beyond on the right bank indicate approximately the head of the present Pool 1. Note the bare bluff under these buildings and a bare area downstream on the left bank, near the present site of the University's power plant.

A map of the Pool 1 area in 1895 (MRC, 1895) indicates that the Mississippi in this reach had 14 islands (See Figure 42). The fast current and shallow depth may have impeded navigation. Several quarries were located on the west (left) bank between the Lake Street Bridge and Franklin Avenue Bridge.

An example of the environmental changes wrought by impounding the Mississippi River is provided by a series of photographs at St. Anthony Falls. Much of the river bottom below St. Anthony Falls Lower Dam lies exposed in the 1926 photograph (Figure 43). The bluffs on the right bank near the steam clouds are bare of cover. Residential and industrial development on the

Table 27. Rare and Endangered Animals of the Upper Mississippi River Basin (FWS, 1970)

Animal	Present Distribution
Indiana Bat *Myotis sodalis* Status endangered with estimated population 500,000.	Midwest and eastern United States from the western edge of Ozark Region in Oklahoma to central Vermont to southern Wisconsin, and as far south as northern Florida.
Timber Wolf *Canis lupus lycaon* Status endangered with estimated population 300-500.	Lake Superior Region of Michigan, Wisconsin, and Minnesota.
Southern Bald Eagle *Haliaeetus leucocephalus* Status endangered with about 230 active nests in 1963.	Nests primarily in Atlantic and Gulf coasts but ranges northward in summer to northern United States and Canada.
American Peregrine Falcon *Falco peregrinus anatum* Status rare with estimated population 5,000-10,000.	Breeds from northern Alaska to southern Greenland south to Baja California; winters in northern United States.
N. Greater Prairie Chicken *Tympanuchus cupido pinnatus* Status rare within Basin.	Resident locally in prairie habitat from central southern Canada south to northeastern Colorado, northwestern Kansas and northeastern Oklahoma east to northern Michigan, Indiana, Wisconsin, Illinois and Missouri.
Greater Sandhill Crane *Grus canadensis fabida* Status rare with an estimated population of 2,000 east of Rocky Mountains.	Breeds locally from southern British Columbia, east to southern Manitoba including Minnesota, Wisconsin and Michigan.
Lake Sturgeon *Acipenser fulvescens* Status rare with estimated size of population unknown.	Distributed throughout Great Lakes Drainage with records from Mississippi and St. Croix Rivers.

Figure 41. View (1890's) looking downstream from St. Anthony Falls showing the debris of the lumbering era. The Stone Arch (Great Northern) Bridge is in the foreground and the (now absent) 10th Avenue Bridge farther downstream. Buildings high on the right bank indicate the approximate head of the present Pool 1.

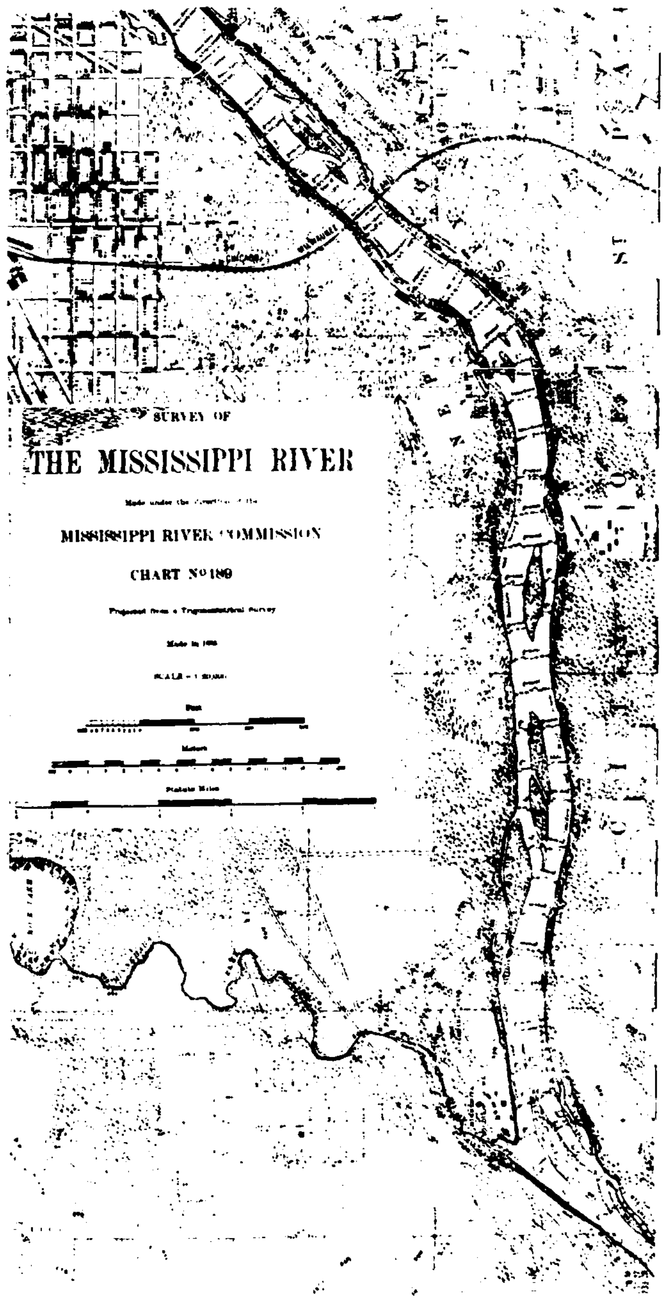


Figure 42. Preproject Environment (about 1895) of Pool 1, from the Franklin Avenue Bridge to Minnehaha Creek (MRC, 1985)

Figure 43. View in 1926 from the 10th Avenue Bridge, showing the St. Anthony Falls lower dam (of the Twin Cities Rapid Transit Company) and the (presently) Burlington Northern Bridge now in Pool 1. Note lack of water at the railroad bridge and naked bluff, especially where steam is rising.

floodplain is seen such as the University power plant (Figure 44). The cement abutment on the left bluff is the Cedar Avenue Bridge then under construction.

By contrast the bluffs presently (1973) seem better vegetated and the river is of sufficient depth to cover the entire bottom of the valley (Figure 45). Development is extensive along the floodplain and bluff top,and bare soil is seen at the Shiely sand and gravel yard on the right bank immediately downstream from the St. Anthony Falls Upper Lock.

An example of the vegetation and animals in the Twin Cities area prior to the project is available in the study by Leisman (1959). He mapped the vegetation of eastern Spring Lake from the General Land Office Survey Maps (See Figure 46). He also summarized the notes by late Dietrich Lange of the vegetation and animals in Spring Lake in the 1920's and early 1930's.

The early settlement (1855) vegetation in Spring Lake consisted of an elm-maple forest on the bottomlands surrounding the marsh now covered by Spring Lake. Oaks fringed the bluff tops, while open prairie with aspen groves lay beyond. Studies by Lange indicate that the dominant plant of the marsh at Spring Lake was the bulrush, Scirpus sp., with many cottonwoods and willows along the margins (See Table 3 in Appendix A, IV).

There are also apparently no records of the early animal populations in the Pool 1 area. Lange's studies of Spring Lake show game fish abounded in the lake, muskrats built their houses throughout the marsh, and countless ducks used the marsh and lake as a stopping point on their annual spring and fall migrations.

Studies made by George (1924) suggest a successional stage from willow to cottonwood on a floodplain downstream of the Ford Plant (See Table 28). This was accompanied by an overall increase in individuals which occurred as the flood level increased elevation. A decrease in flood level elevation during the next year may have caused the reduction in individuals observed; however cottonwood remained the dominant tree.

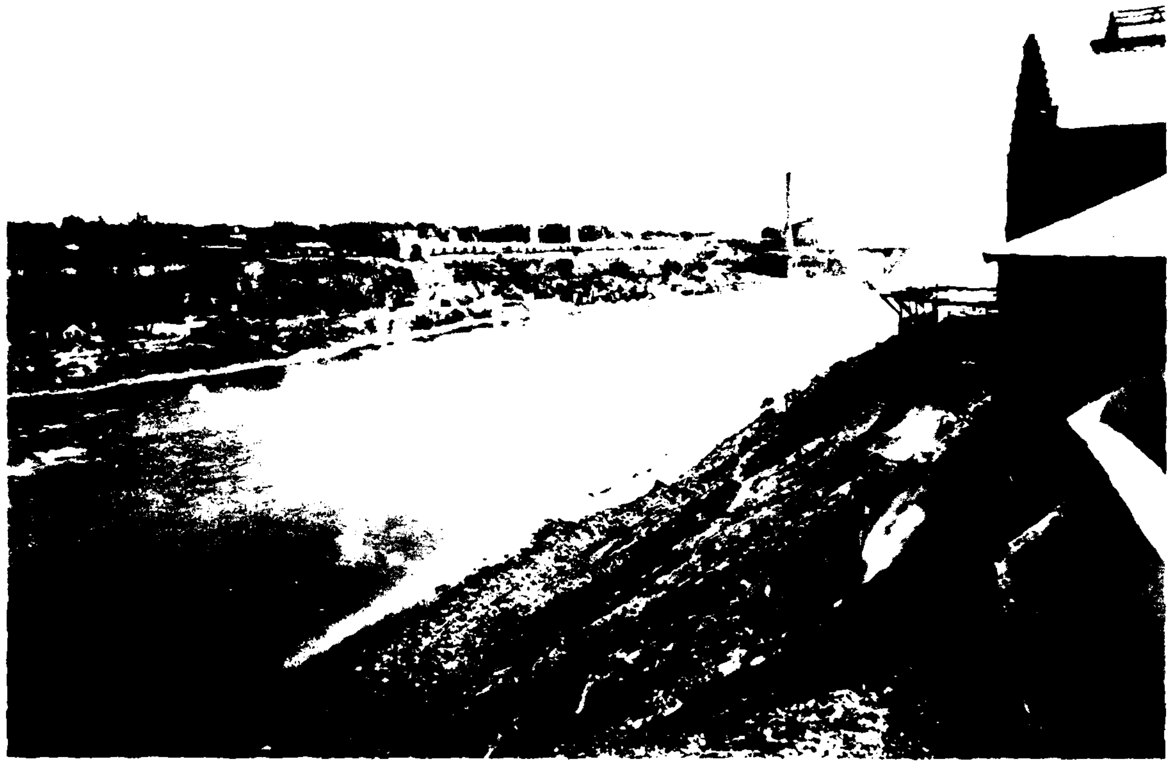


Figure 44. View downstream in 1926 from right bank where steam was rising in previous figure. Cement abutment on the left bank is the Cedar Avenue Bridge which is under construction. Downstream is the University of Minnesota's power plant and the (presently) Burlington Northern Railroad Bridge.

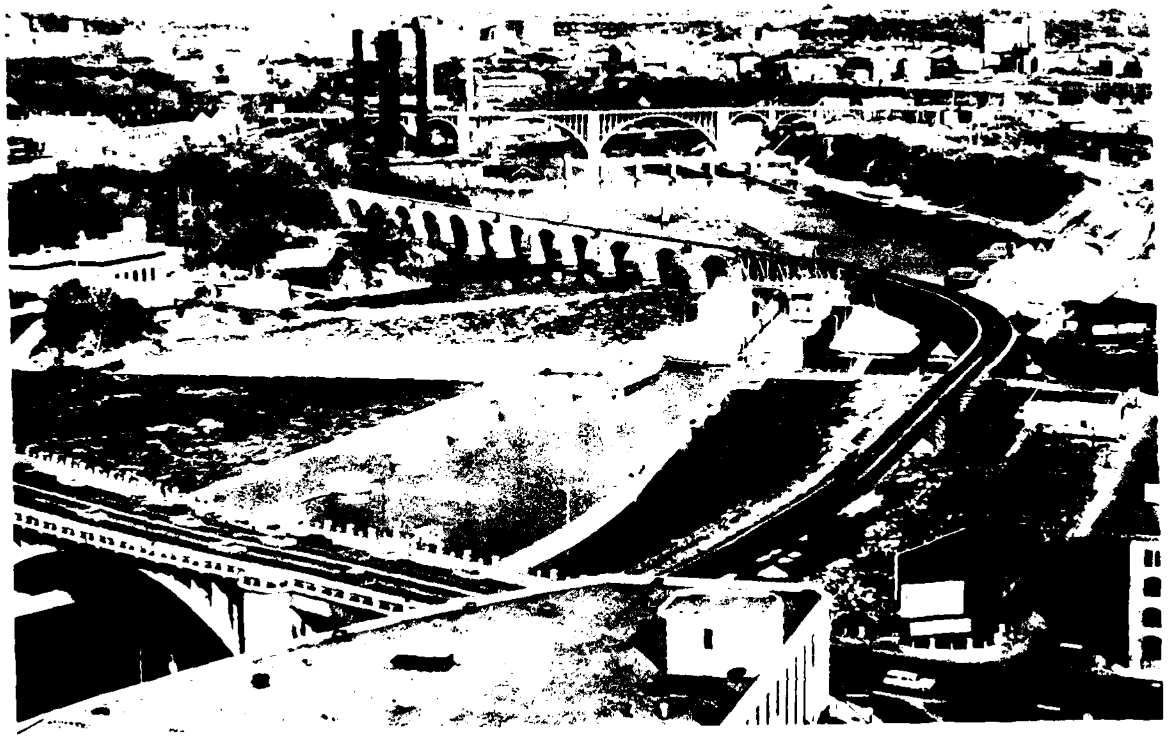


Figure 45. View downstream in 1973 of Upper and Lower St. Anthony Falls, showing the Stone Arch Bridge. The Burlington Northern Bridge is just downstream from the more prominent I-35W Bridge.

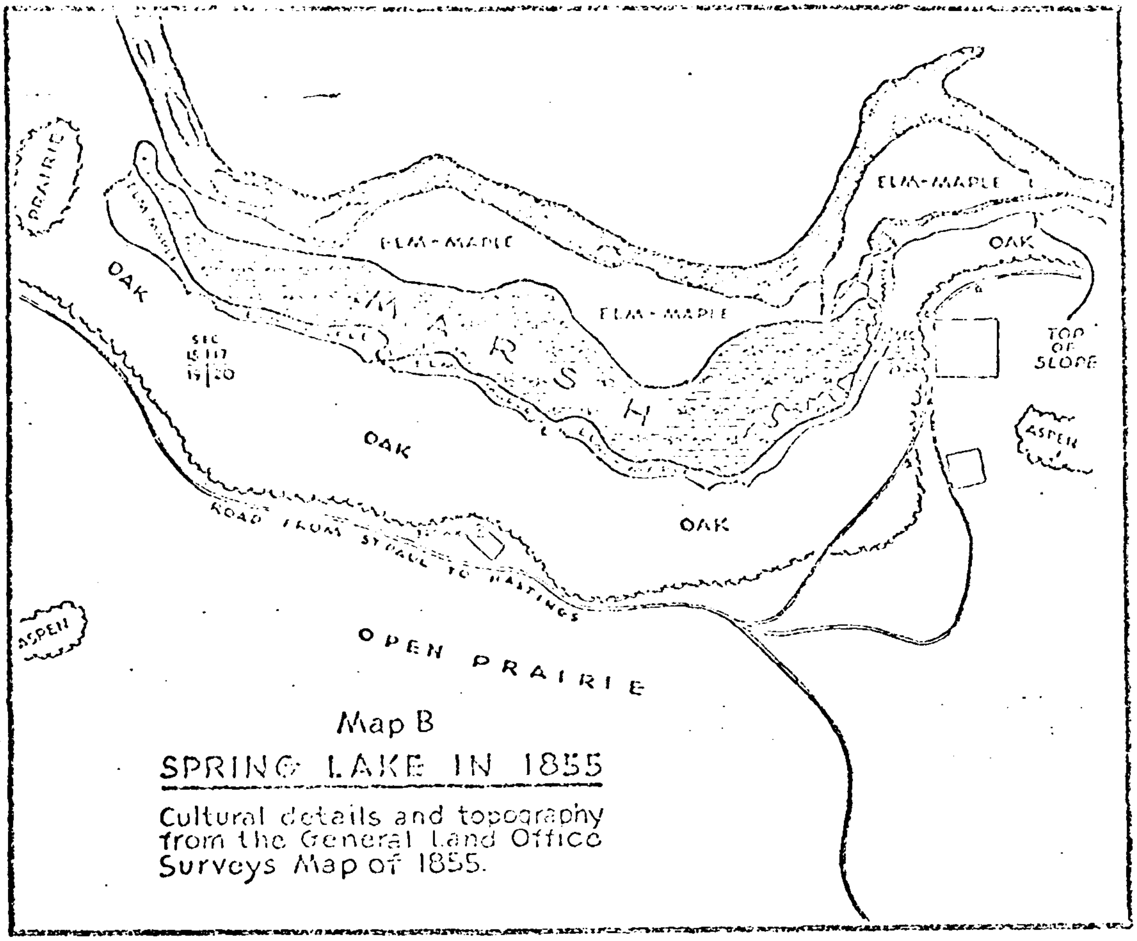


Figure 46. Map of Spring Lake Civil Land Office Survey (Leisman, 1959)

Table 28. H. George (1924) Research (Mississippi River Floodplain at Ford Plant)

Numbers based on 1,000 sq. m. area	Germinations surviving to 1923				Total No. indiv. 1000 sq. m. 1923
	1920	1921	1922	1923	
Salix longifolia	166	1278	2333	722	4500
S. amygdaloides		55	222		278
Populus deltoides		339	38444	1567	40500
Acer saccharinum			556		556
Ulmus americana		289	944		1853
Total no. trees	166	2612	42499	2289	47667
Flood level		716.6	723.3	714.9	

Man-made changes

1814-1920 Dredging, resulting in confining river entirely to channel except in flood.

1923 Burial of east channel from dredging, 15 ft.

An extensive study of the Mississippi River from the Camden Bridge in Minneapolis to Winona was undertaken in 1928 (Wieke, 1928; Woodward, 1930; and Reinhard, 1931).

The condition of the Mississippi in the Twin Cities was described by Reinhard (1931) as follows:

"The Mississippi River enters the Twin City area at Camden, 802 feet above sea level. Station No. 1 is located in north Minneapolis at the Camden Avenue Bridge. The stream here has a velocity at ordinary stages of about one mile per hour and the bottom is for the most part firm and sandy. The average slope above Camden to Little Falls is 2.6 feet per mile although the slope of the entire Mississippi above the Minnesota River is only 1.4 feet per mile. At this station the river has fairly well recovered from the wastes discharged by municipalities in the upper stretches and has not yet received any sewage from the Twin City area.

Shortly after entering Minneapolis the river passes over the St. Anthony Falls where it drops 70 feet and in so doing leaves the prairie and clay banks for a channel that lies for many miles between rocky bluffs of limestone and sandstone. Two miles above the confluence of the Minnesota, the river again falls a distance of 33 feet at the Twin City Lock and Dam, which was constructed in 1914.

Station No. 4 is located directly above this dam in the pool of relatively quiet water which extends about five miles upstream. The Minneapolis sewage and part of the St. Paul wastes are discharged into the river above this point. As a consequence the bottom of the pool is covered with a thick sludge deposit and foul conditions prevail during the summer especially at times of low water discharge.

At Fort Snelling, a few miles below the Lock and Dam, the Mississippi is joined by the Minnesota, a river which does little to alleviate polluted conditions in the main stream. Fifteen miles further on, at Inver Grove, Station No. 8 is located. The river has now received the combined sewage and industrial wastes from Minneapolis, St. Paul, South St. Paul, and Newport. Bottom sludges and their organisms indicate a usual state of heavy pollution. The next sampling point on the river is Station No. 9, above Hastings and above the confluence of the St. Croix River. The water here is deeper and the current more rapid. Bottom sludges are still heavy but no additional sewage has been added between Inver Grove and this station.

In the interval between Hastings and Red Wing the Mississippi receives the waters of the St. Croix from the east and those of the Cannon from the west. The former is a clean stream with a discharge

sufficient to improve appreciably the sanitary quality of the Mississippi; the latter tributary is itself affected by considerable pollution but its discharge is too slight to have any marked effect on the main stream. Below these tributaries and above the town of the Red Wing, Station No. 13 is located.

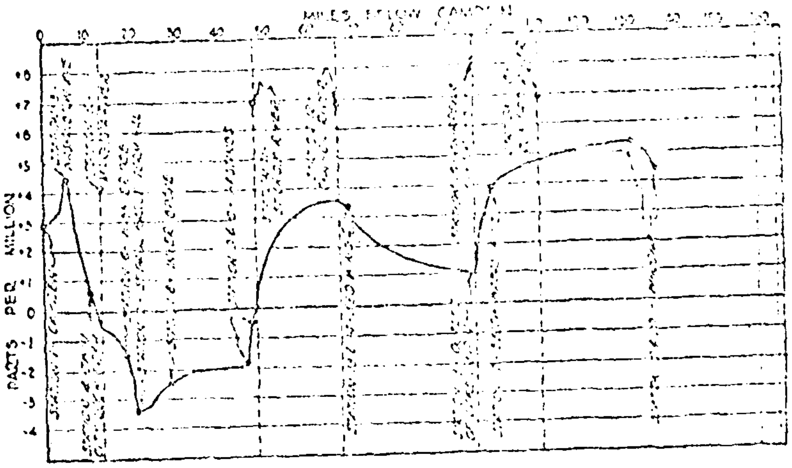
From the mouth of the Minnesota River to the State line the Mississippi is a broad, placid stream averaging 1,000 feet across the main channel. About five miles below Red Wing the river fills out its gorge and forms a lake approximately 22 miles in length and about 2 miles in average width. This section of the river is known as Lake Pepin."

All but one of Minneapolis' and 14 of St. Paul's sanitary sewers emptied into Pool 1 in 1928 (Woodward, 1930). These sewers fouled the water throughout the pool, causing obnoxious smells expecially during periods of low flow and high temperature. In general the Mississippi River water in the Twin Cities was heavily polluted, unfit for consumption and posed a health hazard to the public and livestock. Fish had been nearly eliminated from this reach.

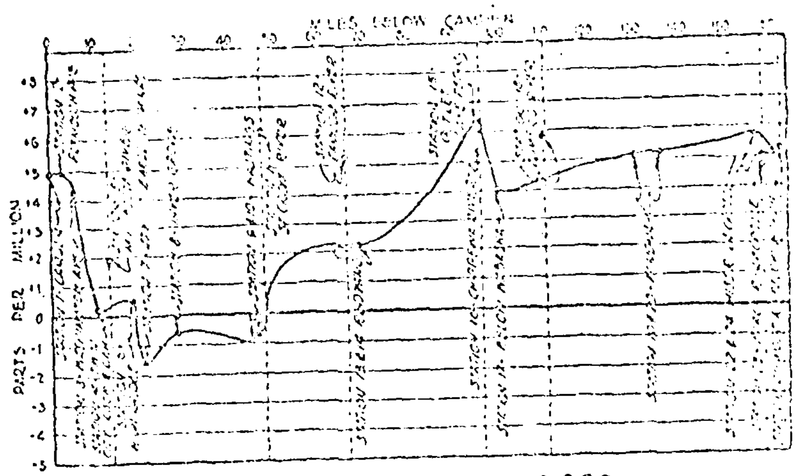
Large quantities of suspended solids from these sewers were deposited in Pool 1. The oxygen resources decreased from about 4.5 mg/1 in June and July of 1928 at the Washington Avenue Bridge to about 0.5 mg/1, at Lock and Dam 1 (See Figure 47). Pollution tolerant planktonic and benthic organisms comprised 60% and 100% respectively of their total populations. Total bacteria amounted to about 200,000 per ml throughout the year.

The pollution from the Twin Cities in 1928 decreased the concentration of dissolved oxygen and increased the concentration of bacteria and the biochemical oxygen demand (5-day demand) downstream to Lake Pepin (Table 29).

Although fish were eliminated from the river from Minneapolis to Hastings, pollution did not seem to have a significant effect upon the phytoplankton (free-floating, microscopic plants) (See Table 30).



WINTER CONDITIONS 1928



SUMMER CONDITIONS 1928

Figure 47. The Effect of Pollution from the Twin Cities and Other Cities Upon the Oxygen Resources of the Mississippi River from the Camden Bridge in Minneapolis to Winona, Minnesota (Oxygen resources - dissolved oxygen minus biochemical oxygen demand) (Reinhard, 1931)

Table 29. Summary of Physical, Chemical, Bio-Chemical and Bacteriological Analyses for all Plankton Stations on the Mississippi River, 1928 (Reinhard, 1931)

Station	Location	Color			Turbidity			Total Hardness			Alkalinity			Chlorides		
		Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
1	Camden Ave. Bridge....	...	..	..	70	5	13	203	168	187	209	99	145	14	2.[illegible]	6.56
4	Lock and Dam, Mpls....	...	..	..	65	6	15	218	10[illegible]	140	200	1[illegible]	146	16.7	5.5	16.5
8	Inver Grove..........	...	..	..	120	10	39	218	124	172	219	114	155	34.2	7.6	15.5
9	Above Hastings.........	120	27	51	60	4	22	253	138	190	243	115	159	16.5	1.0	5.5
13	Above Red Wing.........	100	15	53	240	0	24	190	103	1[illegible]	185	101	131	9.0	0.5	[illegible]
15	Outlet of Lake Pepin....	75	20	45	10	0	5	198	129	151	193	105	135	9.0	0.0	3.3
17	Below Wabasha.........	90	13	53	200	2	17	172	89	123	179	60	110	7.0	0.0	1.[illegible]
19	Above Winona.........	110	36	64	135	0	26	156	40	111	159	45	100	4.5	0.0	1.3

Station	pH Value			Dissolved Oxygen			5-Day Demand			Bacteria per c.c., 37° C., 48 hrs.			*B. coli* per c.c.		
	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
1	[illegible]	7.4	7.96	11.6	4.1	8.2	6.6	[illegible].7	2.4	11,500	80	1,726	100	0.1	11
4	[illegible]	7.4	7.8	12.7	2.9	6.3	8.4	2.2	4.2	820,000	5,700	123,257	10,000	10	1,591
8	[illegible]	7.5	7.8	11.5	2.3	6.7	14.0	3.1	6.0	1,000,000	8,[illegible]	156,924	10,000	100	2,07[illegible]
9	[illegible]	7.3	7.7	11.1	1.5	5.8	11.1	1.3	3.0	220,000	[illegible]	69,345	1,[illegible]	10	545
13	[illegible]	6.5	7.65	10.5	2.6	6.3	4.5	1.5	2.7	92,[illegible]	475	21,659	1,000	10	159
15	[illegible]	7.3	7.9	11.9	3.7	7.3	4.7	1.1	2.2	5,[illegible]	41	642	10	0.02	1
17	[illegible]	7.2	7.8	11.3	4.1	7.2	3.9	0.6	1.7	7,700	55	1,[illegible]	10	0.1	5
19	[illegible]	7.2	7.7	11.7	6.6	8.2	5.1	1.1	2.3	21,500	150	2,712	100	1	14

Table 30. Predominant (pd), Dominant (d) and Subdominant (sd) Plankton Species at the Various Stations (Reinhard, 1931)

Organisms	Mississippi River Stations							
	1	4	8	9	13	15	17	19
Cyclotella meneghiniana	pd	pd	pd	pd	pd	pd	pd	pd
Asterionella f. gracillima	d	d	d	d	d	d	d	d
Lysigonium granulata	sd	d	d	d	d	d	d	d
Synedra delicatissima	sd	d	d	d	d	d	d	d
Synedra ulna	d	d	d	d	d	sd	sd	sd
Scenedesmus quadricaudus	sd	sd	sd	sd	sd	sd	d	d
Aphanizomenon flos-aquae				sd	sd	d	sd	sd
Diatoma vulgare	d	sd	sd					
Cocconeis placentula	d	sd						
Gyrosigma spenceri			sd					
Stephanodiscus niagarae	sd	sd	sd	sd	sd	sd	sd	sd
Actinastrum han. fluviatile			sd	sd	sd	sd	sd	
Lysigonium varians	sd	sd		sd				sd
Scenedesmus dimorphus					sd	sd	sd	sd
Pandorina morum								
Fragilaria crotonesis								
Fragilaria capucina								

Note: 1) Reinhard's method of determining relative abundance was to tabulate the ten most abundant species from each station. The species with the highest abundance was called predominant (pd); the second to fifth most abundant species were called dominant (d); and those raking six through ten were called subdominant (sd).

2) See Table 29 for location of the sampling stations.

Land Use

Urban development dominates the bluff top and floodplain of Pool 1; virtually no land is vacant (See Figure 48). The bluffs and limited floodplain in the upper 1.5 miles of the pool are occupied by industry and institutions, principally the Minneapolis barge terminal and three other barge docks, the University of Minnesota and several hospitals (Figures 49 and 50).

Downstream from the Washington Avenue Bridge to Lock and Dam 1, the remaining floodplain and the bluff slopes and brims in Pool 1 are parks bordered by residences (See Figure 51). Below the bluffs, most of the park

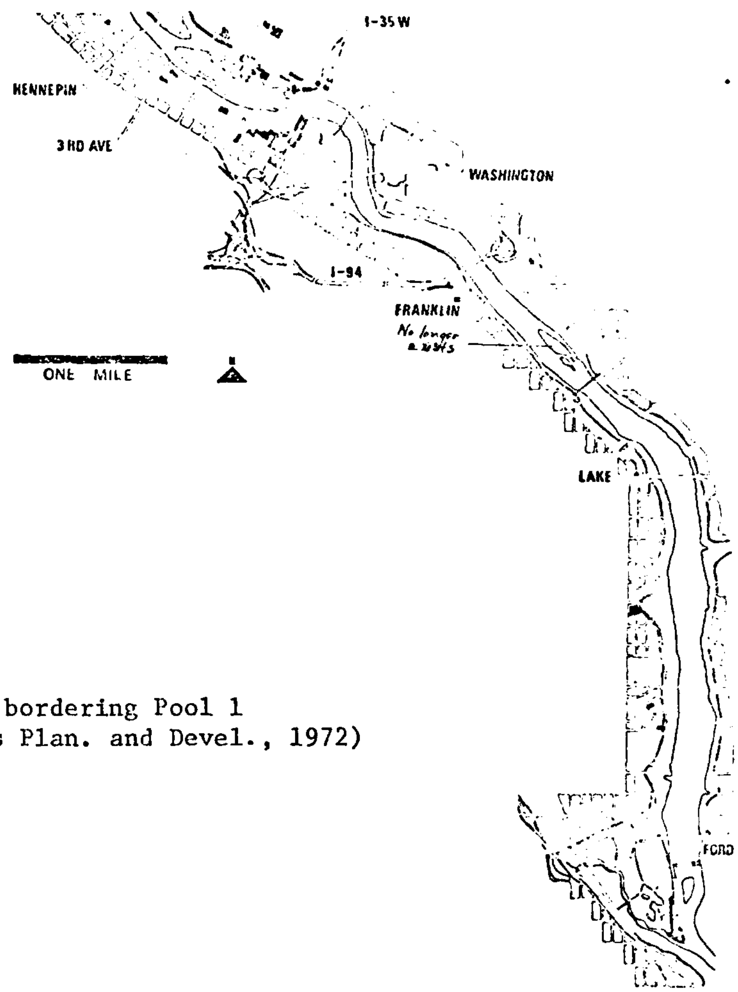


Figure 48. Vacant land bordering Pool 1
(Minneapolis Plan. and Devel., 1972)

area is undeveloped open space, including some spoil piles (See Figure 8 in Section 1; Figures 11, 12, 26 and 31 in Section 2).

This steep-walled, undeveloped reach of the gorge provides the largest open space (5 miles), and the greatest relief from the highly urbanized Twin Cities area. Indeed, the view from within the gorge creates the illusion that one is part of a larger primitive setting; the crowded urban area can nearly be forgotten. Numerous trails have been made by the frequent hikers and picnickers. Where these trails rise to the bluff top, significant erosion of the steep slope can occur.

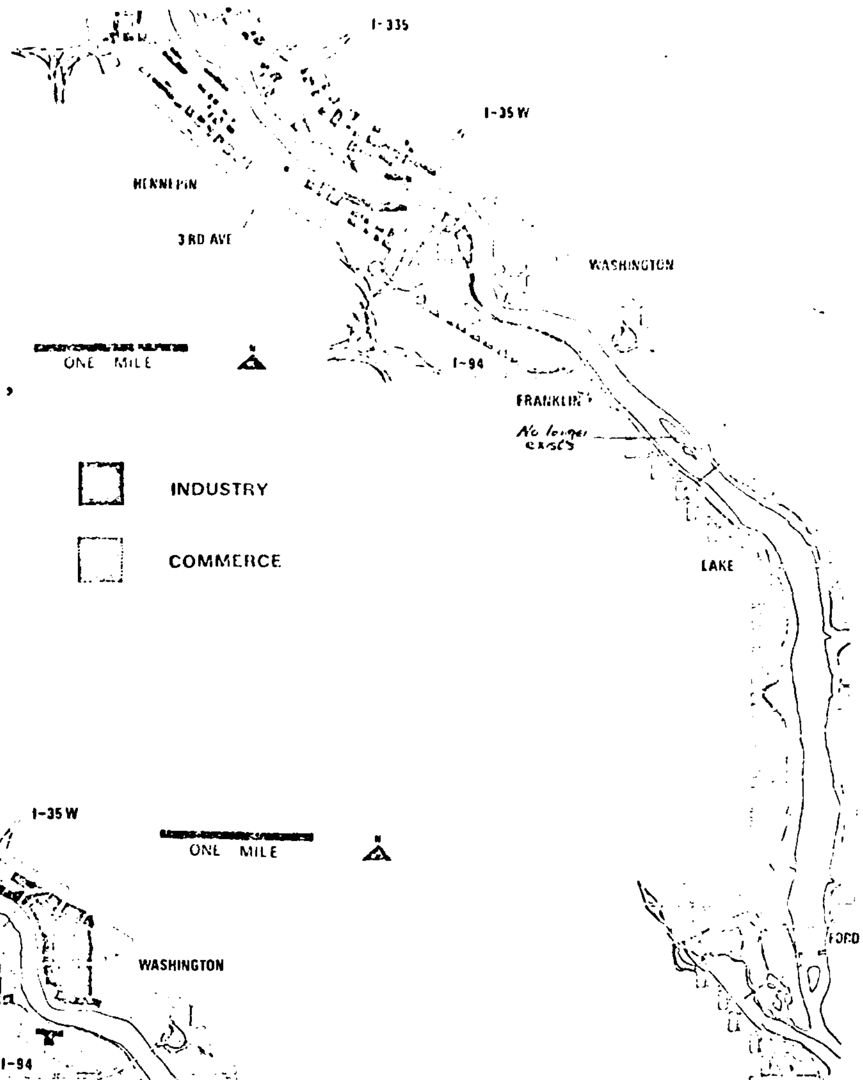


Figure 49. Industrial and Commercial Sites Bordering Pool 1 (Minneapolis Plan. and Devel., 1972)

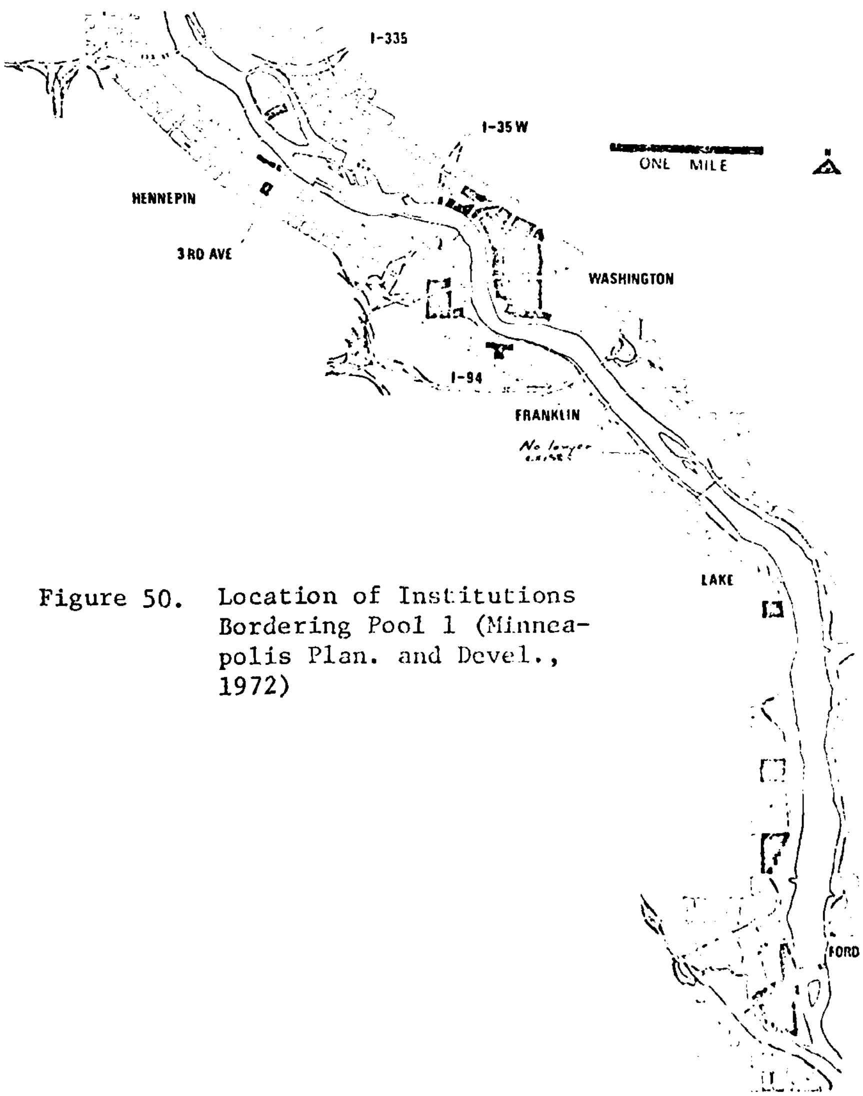


Figure 50. Location of Institutions Bordering Pool 1 (Minneapolis Plan. and Devel., 1972)

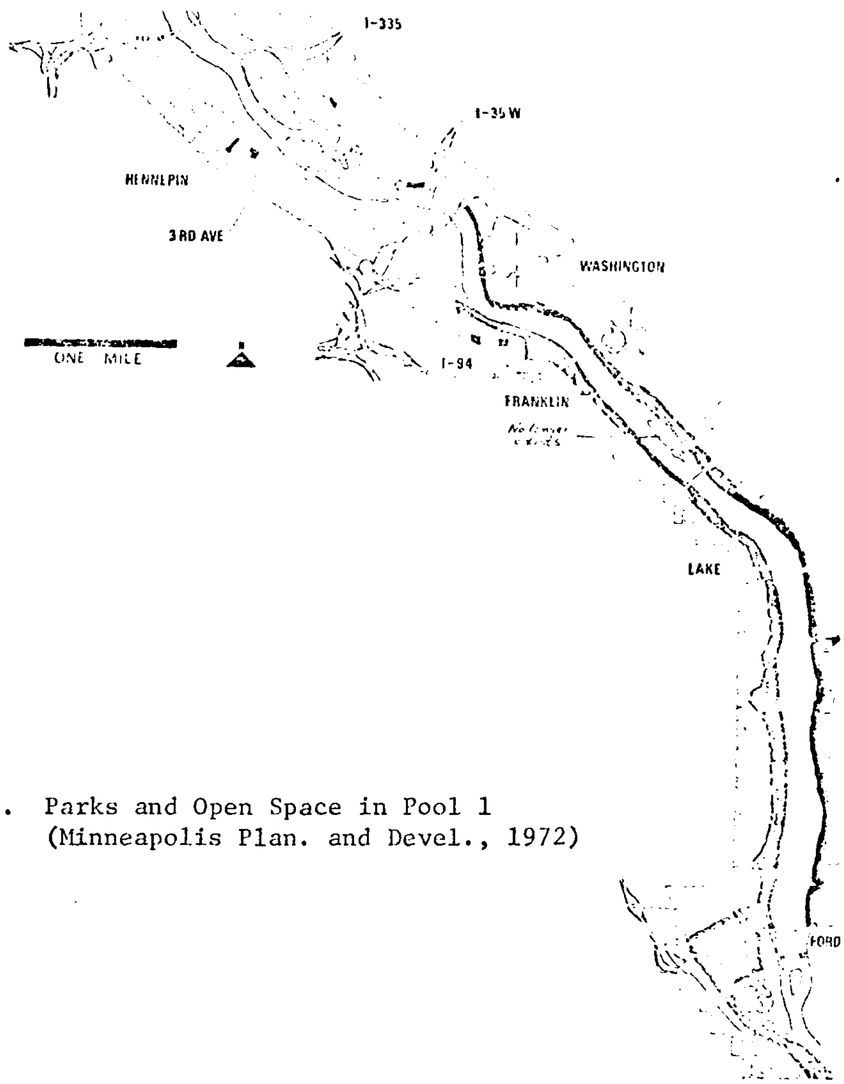


Figure 51. Parks and Open Space in Pool 1
(Minneapolis Plan. and Devel., 1972)

Development of this relatively primitive area of the gorge in Pool 1 probably would best be restricted the minimum necessary to provide public access while reducing their impact. For instance the trails should be relocated and surfaced to reduce erosion, yet the informal character of these paths should be maintained. With slight modification these paths, or portions thereof, could be self-guiding nature trails and snowshoe and cross-country ski trails.

Motor vehicles and buildings for public convenience probably should be restricted to the bluff top, except possibly at the two large spoil sites.

These sites, when properly contained could provide several dune-beach recreation areas capable of handling relatively large numbers of people. At the same time erosion could be minimized by promoting revegetation in strips perpendicular to the shoreline between spoil sites (See Figure 52). This pattern of vegetation occurs at the spoil site downstream from the Franklin Avenue Bridge, which, if more closely spaced, would increase aesthetics and decrease erosion (See Figure 11 in Section 2).

The recent annual increase in tons of goods shipped by river (See Socio-economic Section) attest to the continued economic growth in the upper Mississippi River basin. This growth is particularly evident in the metropolitan areas as shown by housing developments, urban renewal, development of industrial parks, and highway construction.

About 100 square miles of the 3000 square mile Twin Cities metropolitan area, or an area about 10 times downtown Minneapolis, is anticipated to go into urban development. Part of this area will be devoted to highway construction. Freeway construction planned or under construction are I94, I35W and I335.

In light of this growth, the Metropolitan Council has adopted a Parks and Open Spaces Program to guide municipalities in preserving undeveloped areas for aesthetic, recreational, historical and productive uses. Examples of such sites include floodplains, wetlands, shorelines, steep slopes, aquifer recharge areas and wooded sites.

Evidence of this need was indicated in 1967 when a survey showed only about 1/10 of the 310 miles of shoreline along the major rivers in the metropolitan area to be in public ownership. Also only 42 of the 704 metropolitan lakes were fronted with parks of 15 or more acres, and only 40 lakes had public or commercial beaches. The Council's program advocates completing aquisition of 12 sites, consideration of 22 others, and the purchase and development of 107 waterside parks.

Figure 52. Recommended Method of Spoil Disposal, How Strips of Spoil Lying Between the Spoil and Perpendicular to the Current Will Revegetate Rapidly, Providing a Screen to Wind and Water Erosion (Colingsworth and Gudmundson)

Other types of areas suggested include a trail network, protection open space (such as flood and drainage ways), open space for industrial and agricultural production, and scenic open space.

Development along Pool 1, which is in the heart of the Twin Cities, is residential or institutional along much of the lower reach blufftops, except for a narrow strip of parkland along the very edge. The bluffs and river banks in the upper reach, upstream from the University of Minnesota, is crowded with commercial and industrial sites. These plus urban renewal and dredging have created numerous bare-soil sites (See Table 31).

A massive urban renewal project is underway on the right bank near the head of Pool 1. The Cedar-Riverside Project will result in a population of about 30,000 people in high-rise apartments. This project includes the transformation of the old Minneapolis terminal into a river-side park.

Table 31. Bare Soil Areas in Pool 1

River Mile	Bank	Location
853.2	L	Site just downstream of hydroelectric plant at Lower St. Anthony Falls Dam.
853.1	L &R	Barge terminals and fill (R/B).
852.6-7	R	Barge terminals.
852.0	L	Spoil.
851.0	L	Spoil.
850.5	R	Spoil.
849-50	R	Spoil.
848.1	L	Old Spoil.

SOCIOECONOMIC SETTING

The socioeconomic aspects of the environmental setting are discussed (1) by identifying the three-way subdivision of socioeconomic activities used in this report and (2) by presenting an overview of these activities in Pool 1 as they also relate to the Northern Section of the Upper Mississippi River.

Three Subdivisions of Socioeconomic Activities

It is useful to divide a discussion of the socioeconomic setting of the study area of the Upper Mississippi River into (1) industrial activity, (2) recreational activity, and (3) cultural considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on farms, in barge operations, commercial

dock facilities, lock and dam operations, and commercial fishing. While it is probably most desirable to measure industrial activity in terms of jobs or dollars generated, lack of available data makes this impossible in the present study. As a result indices of this industrial activity -- such as tons of commodities moved, industrial facilities constructed, or pounds of fish caught -- are generally used.

Recreational Activity

Recreational activity has two effects of interest. One is the psychological value to the users themselves of being near or on the Mississippi River for leisure activities. A second effect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure-time activities of people using the Mississippi River for recreational purposes; examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational activities frequently use units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor-days. It is often very difficult to find such measures for a particular pool on the Mississippi River. Where such data are available -- such as pleasure boat lockages -- they are used. Where they are not available -- such as fishermen using a specific pool -- proxy measurements are used; for example, number of sport fishermen observed annually by lock and dam attendants are taken as a measure of fishing activity in the pools -- even though this is not as precise a measure as desired. Problems involved with placing dollar values on these recreational activities are discussed in Section 6.

Cultural Considerations

Cultural considerations are the third component of the socioeconomic setting. These considerations include three kinds of sites of value to society: archaeological sites, historic sites, and contemporary sites. These sites can include such diverse physical assets as burial mounds,

historical battlegrounds or buildings, or existing settlements of ethnic groups such as Amish communities. Because of the difficulty of placing any kind of value on such sites,they are simply inventoried in the present study.

Overview of Socioeconomic Activities in Pool 1

The industrial, recreational, and cultural aspects of Pool 1 are discussed below in relation to the entire Northern Section of the Upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication tying together the industrialized East with the agricultural Middle West as well as the varied economies of the North and South.

Historical Development of the Waterway. The development of the Northern Section of the Upper Mississippi as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high-volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competitive with other forms of transportation. It is noteworthy that competing systems of land transportation such as railroads and highway trucking utilize the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the Mississippi River Valley is intensively utilized to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi River was a transportation corridor for the Indians. It facilitated the primitive barter economy and served as a route for other forms of social and cultural communication and contact.

In its primitive condition, the Upper Mississippi was characterized by numerous rapids and rock obstructions. Fluctuations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before commerical use of the river approaching modern tonnages could take place. Prior to improvements, such traffic was limited to log rafts and shallow-draft boats which could navigate the shallow, changing river between the Falls of St. Anthony and the mouth of the Ohio River.

The necessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823, steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the U. S. and the relative slowness and hazards of navigation marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river.

As the population and industry of the Upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than the earlier steamboats. The need for coal in the Upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920's large grain shipments from Minneapolis began.

Although four-foot and six-foot channels had been authorized in recognition of the increasing role of the river in the transportation network of the U. S. and technological developments in barges and tugs led to the authorization of a nine-foot channel to Minneapolis in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps' activities. For example, the following factors complicate the problem of data analysis during the period prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segments of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with better methods of statistical collection.
2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's due to the construction of locks and dams in the St. Paul District.
3. From 1941 to 1945 all forms of transportation were utilized for the war effort without regard to maximizing economic return. Therefore, data for these years (as with the 1930's) does not necessarily reflect a normal period of transportation on the Upper Mississippi.

Barge Shipments. Table 32 shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

In more recent years, data are available for the St. Paul District. Table 33 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

Table 32. River Shipment from 1920 through 1945
(OCE, selected years)

Year	Total Tonnage (short tons) Shipments and Receipts*	River Segment
1920	630,951	Mpls. to Mouth of Missouri River
1925	908,005	Mpls. to Mouth of Missouri River
1926	691,637	Mpls. to Mouth of Missouri River
1927	715,110	Mpls. to Mouth of Missouri River
1928	21,632	Mpls. to Mouth of Wisconsin River
1929	1,390,262	Mpls. to Mouth of Ohio River
1930	1,395,855	Mpls. to Mouth of Ohio River
1935	188,613	St. Paul District
1940	1,097,971	St. Paul District
1945	1,263,993	St. Paul District

*Tonnages exclude ferry freight (cars and other) and certain cargoes-transit.

Table 33. River Shipment from 1962 through 1971
(S.P.D.-NCS, selected years)

Year	Total Traffic St. Paul District*
1962	8,168,594
1963	9,266,361
1964	9,621,336
1965	9,205,538
1966	11,346,457
1967	11,618,849
1968	10,736,350
1969	12,647,428
1970	15,423,713
1971	15,070,082
1972**	16,361,174

**Estimated

When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between Minneapolis and the mouth of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was due to a large degree to grain shipments from the District and to an increase in receipts of coal.

In 1928 data were collected on receipts and shipments for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District, and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, 21,600 tons were shipped and received. By 1940, tonnages handled reached 1,000,000 tons annually, when the lock and dam system and the nine-foot channel were virtually complete. Tonnages reached 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,000,000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972 this had doubled to 16,000,000 tons.

Table 34 shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River in 1971.

The commercial lockages through the locks in the study area are shown in Figure 53 and provide another indication of the recent increase in barge traffic. From 1960 to 1972 the number of lockages in the portion of the River between Lock and Dam 2 and Lock and Dam 10 increased by about 600. The most dramatic increases occurred, however, in the St. Anthony Falls and Pool 1 area; Figure 53 shows that commercial lockages through the three locks in this area increased by more than 1,000 lockages each during the period, which includes the opening of the Upper St. Anthony Falls Lock and Dam.

Table 34. River Trips in 1971 (OCE, 1971)

Transportation Mode	Upbound	Downbound
Self-Propelled		
Passenger and dry cargo	1,900	1,875
Tanker	3	2
Towboat or Tugboat	8,433	8,419
Non-Self-Propelled		
Dry cargo	25,250	25,237
Tanker	7,312	7,311
TOTAL	42,898	42,844

The shipping season for most of the Mississippi River within the St. Paul District is usually eight months, from mid-April to mid-December. The navigable rivers maintained and operated by the St. Paul District should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne commerce traffic patterns showed that the average miles per ton on the Upper Mississippi River Waterway System ranged from 700 to 800 miles. This indicates that the great bulk of shipments and receipts have origins or destinations outside the St. Paul District. Each pool then in addition to its own shipments and receipts contributes to the economic benefits enjoyed by the system as a whole. Thus, any measure of the economic benefits of the river commerce on an individual pool must include the benefits that it contributes as a necessary link in the Upper Mississippi system.

Commercial Dock Facilities. For access to the barge traffic on the Upper Mississippi River many companies maintain docks. Some of these have elaborate facilities for loading or unloading specialized cargoes with which

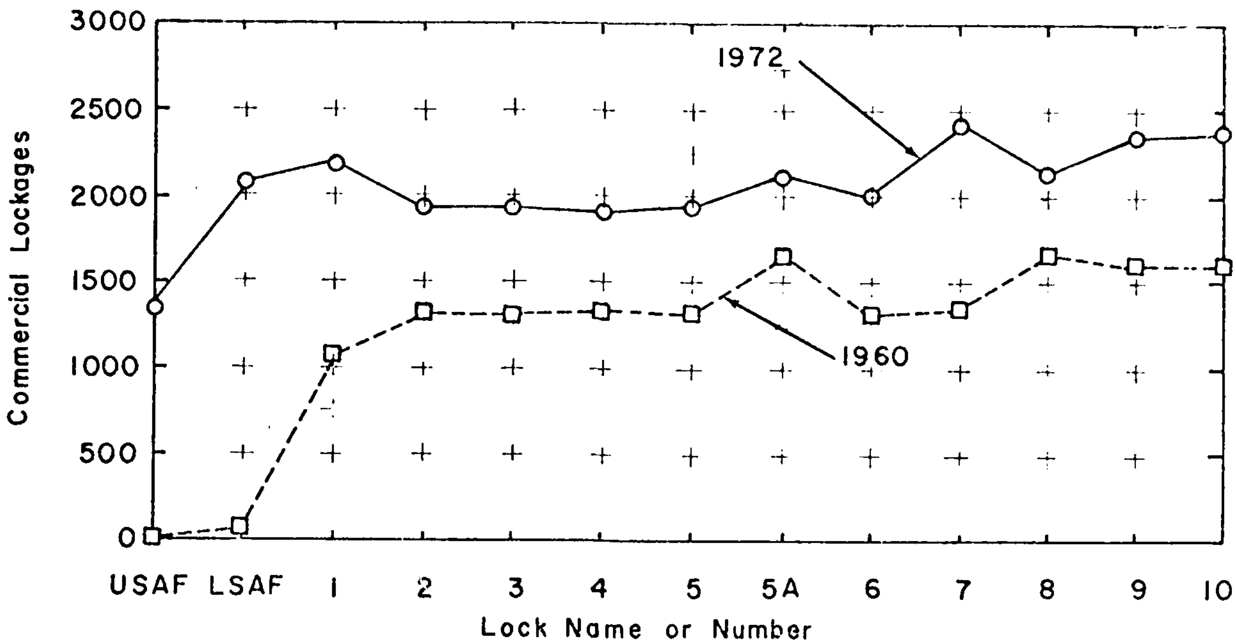


Figure 53. Commercial Lockages in Upper Mississippi River in 1960 and 1972 (S.P.D.-NCS, 1960 and 1972)

they deal -- coal, oil, grain, and gravel and crushed rock. The facilities vary appreciably with individual pools. Pool 1 had 8 such docks, but presently there are 4, three of which are located at the Minneapolis terminal under the Washington Avenue Bridge (See Table 35). This terminal is being relocated in St. Anthony Falls Upper Pool. Next year the Minneapolis terminal will be converted to a park. The only commercial dock will be the University of Minnesota coal dock at Mile 853.1.

Table 35. Commercial Docks in Pool 1

Mile	Company
853.1	University of Minnesota coal dock
852.5	McMillan Grain Co. dock
852.4	Municipal coal dock
852.0	Kack Refining Co. dock

Commercial Fishing

Although commercial fishing is an important economic activity in some pools in the St. Paul District of the Upper Mississippi River it does not occur in Pool 1 nor has it in recent history. The narrowness of the river and thus the lack of shallow waters in this pool and the formerly significant level of pollution make commercial fishing unlikely; lack of habitat continues to limit commercial fishing. Figure 54 illustrates the wide variation in commercial catches in the St. Paul District.

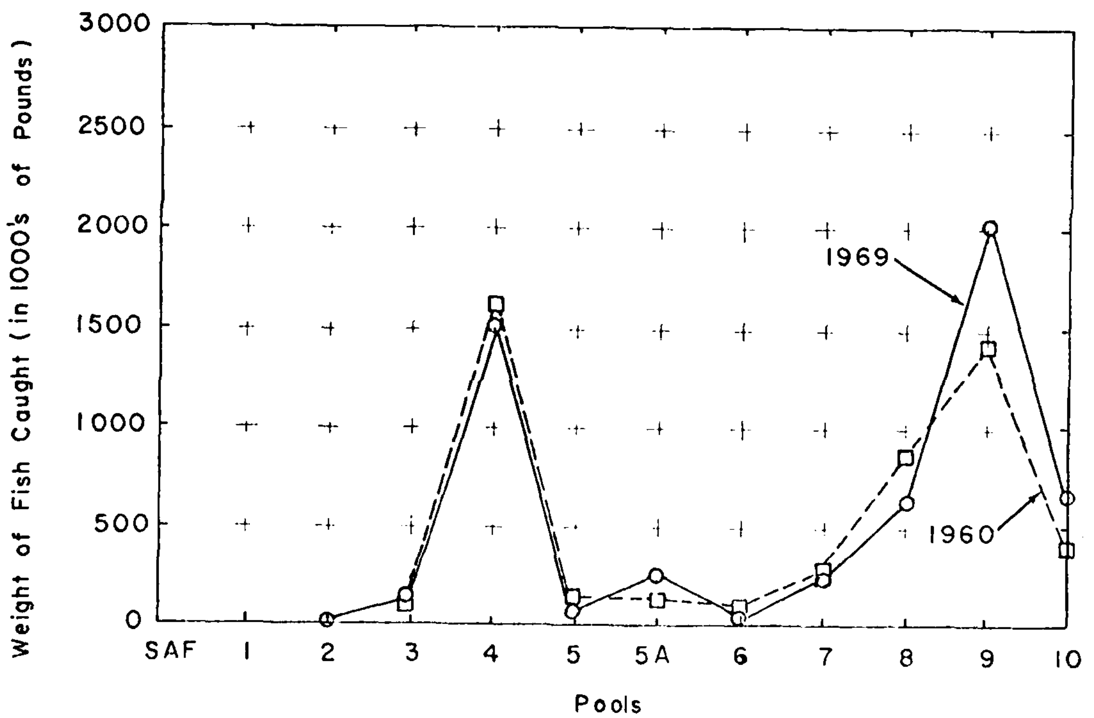


Figure 54. Thousands of Pounds of Fish Caught Annually by Commercial Fishermen in Upper Mississippi River Pools in 1960 and 1969 (UMRCC, selected years)

Recreational Activity

In addition to the industrial activity described above, the Northern Section of the Upper Mississippi River has provided innumerable recreational opportunities for the entire region it serves. Even prior to Congressional authorization of the 4 1/2 foot channel in 1878 -- the first comprehensive project on the Upper Mississippi, from the mouth of the Ohio River to St. Paul -- settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wilderness of the early nineteenth century meant that recreational uses of the upper River were few. Thus, boating then was not primarily for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish or game were sold or traded for other necessities required for daily living.

As the twentieth century dawned, increasing leisure time accompanying the settlers' higher standard of living led to greater recreational uses of the Upper Mississippi River. Segregating present-day recreational uses of the study area due to Corps' operations from those existing in 1930, prior to the nine-foot channel, presents problems. These arise because of the difficulty of isolating the increased recreational uses of the river caused by more people in the region, higher standards of living, and increased leisure from those caused by improved navigational and other recreational opportunities.

A significant portion of the recreational activity on the Upper Mississippi is due (1) to the improved navigation opportunities for large pleasure craft on the river, and (2) to improved fish and game habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not always realized (for example in Pool 1) because increased industrialization along the river has polluted the river and has reduced the available hunting areas, which often more than offset the increased habitat.

Data for 1963, which includes the St. Anthony Falls pools with Pool 1, shows that picnicking and fishing are the most frequent persuits of visitors to this segment of the Mississippi River (See Table 36). Swimming and camping were non-existant, primarily due to lack of sites and water quality, respectively.

Presently there probably is greater use of the river as indicated by the number of pleasure boats in 1972 (See Figure 55). During 1973 hiking, fishing and swimming also seemed popular in Pool 1.

Boating Activity and Related Facilities. As noted above, much of the increased boating in the study area of the river -- and virtually all of it for the deeper-draft pleasure boats -- is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 59 illustrates the dramatic growth in pleasure boating in the study area from 1960 to 1972. The figure shows that number of pleasure boats moving through each lock in the study area increased by an average of about 1,500 boats during the twelve-year period. It can be seen that the number of pleasure boats moving through the Lower St. Anthony Falls Lock and Lock 1, those at each end of Pool 1, increased by about the average for the District during this period.

Table 36. Entire Pool 1 and St. Anthony Falls Pools Visitation -- 1963

	Annual - 1963		Peak month - August	
Activity	Percent of Total	Number	Percent of Total	Number
Camping	0	0	0	0
Picnicking	57.1	7,200	73.5	3,010
Boating	2.4	300	1.2	50
Fishing	39.7	5,000	24.8	1,020
Water-skiing	0.8	100	0.5	20
Swimming	0	0	0	0
TOTAL	100	12,600	100	4,100

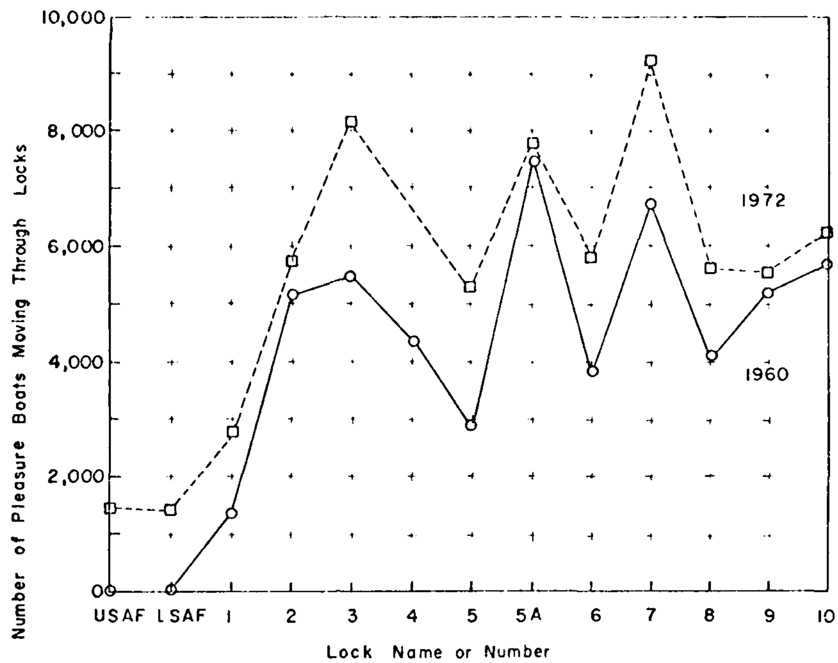


Figure 55. Pleasure Boats Moving Through Upper Mississippi River Locks in 1960 and 1972 (S.P.D.-NCS,selected years)

There are no Federal or State parks in the area backing Pool 1. The only public use facilities are found and managed by the Minneapolis Park Board (see Table 37) and St. Paul Community Services (park system). The facilities offered are limited. The only pleasure boats kept in Pool 1 are rowing shells. The narrowness of the gorge and navigational hazards involved in the competition for space with commercial barges further discourages pleasure boating at least to the extent that most other pools are utilized.

Sport Fishing and Hunting. Precise measures of the number of sport fishermen using a specific pool are not available. Although creel census data are available for Pools 4,5, and 7 in the study area, comparable data do not exist for the majority of the pools. Probably the best data available are the number of sport fishermen observed annually by attendants at lock and dam

Table 37. Major Existing Public-Use Facilities - Pool 1 and St. Anthony Falls Pools (S.P.D.-NCS, 1972)

Site	River Mile	Bank	Facilities developed	Land managed by	Landowner	Boat launching ramp: Number of Lanes	Boat launching ramp: Surface	Parking at ramp: Number of spaces	Parking at ramp: Surface	Number of acres	Other facilities or remarks
Minneapolis Rowing Club	849.2	R	Minneapolis Rowing Club	Minneapolis Rowing Club	Minneapolis Park Board	-	-	15	Black-top	0.5	Docking facilities only. Open to the public.
River flats	852.3	L	Minneapolis Park Board	Minneapolis Park Board	Minneapolis Park Board	1	Gravel	Very limited	Gravel	-	Minneapolis show-boat. Most land is leased to University of MN and used for parking.
Riverside Park	852.0	R	Minneapolis Park Board	Minneapolis Park Board	Minneapolis Park Board	0	-	-	-	-	Picnic tables, hiking and biking trails.

Note: Other sites include Summit Avenue Park, Minneapolis Boulevard Park, St. Paul East River Road Park and Minnehaha Park which are located along the brim of the bluffs in Pool 1.

sites. Attendants to each lock and dam observe the river pool areas above and below their site at 3:00 p.m. each day and record the combined number of sport fishermen seen; the data are not recorded separately for the pool above and below the lock and dam. The annual data are simply a sum of these daily estimates.

The number of sport fishermen observed by attendants at each lock and dam in the study area are shown in Figure 56 for the years 1960 and 1970. There has been little change during the ten-year period of the number of sport fishermen observed. Because fish tend to seek water with a high concentration of dissolved oxygen and the dams tend to aerate the water, the bulk of the sport fishermen tabulated in Figure 56 are probably in the pool downstream from the lock and dam cited on the horizontal axis of the figure. The figure shows that in 1970 fewer sport fishermen were observed from either end of Pool 1 than at any other lock and dam except Pool 2. The urban industrial nature of the pool and the high degree of water pollution discourages most fishing in Pool 1.

Sport hunting along the Mississippi River study area is large. However, due to the narrowness of the pool and its location in the heart of the metropolitan area hunting does not take place in Pool 1.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data are lacking, it is generally difficult to describe the magnitude of this category of recreation and to isolate the effect of Corps' operations on these recreational activities in each pool. To assist sightseers, the Corps of Engineers operates eight overlooks at locks and dams in the study area. In addition, a variety of parks exist along the river that are available for sightseeing and other recreational activities.

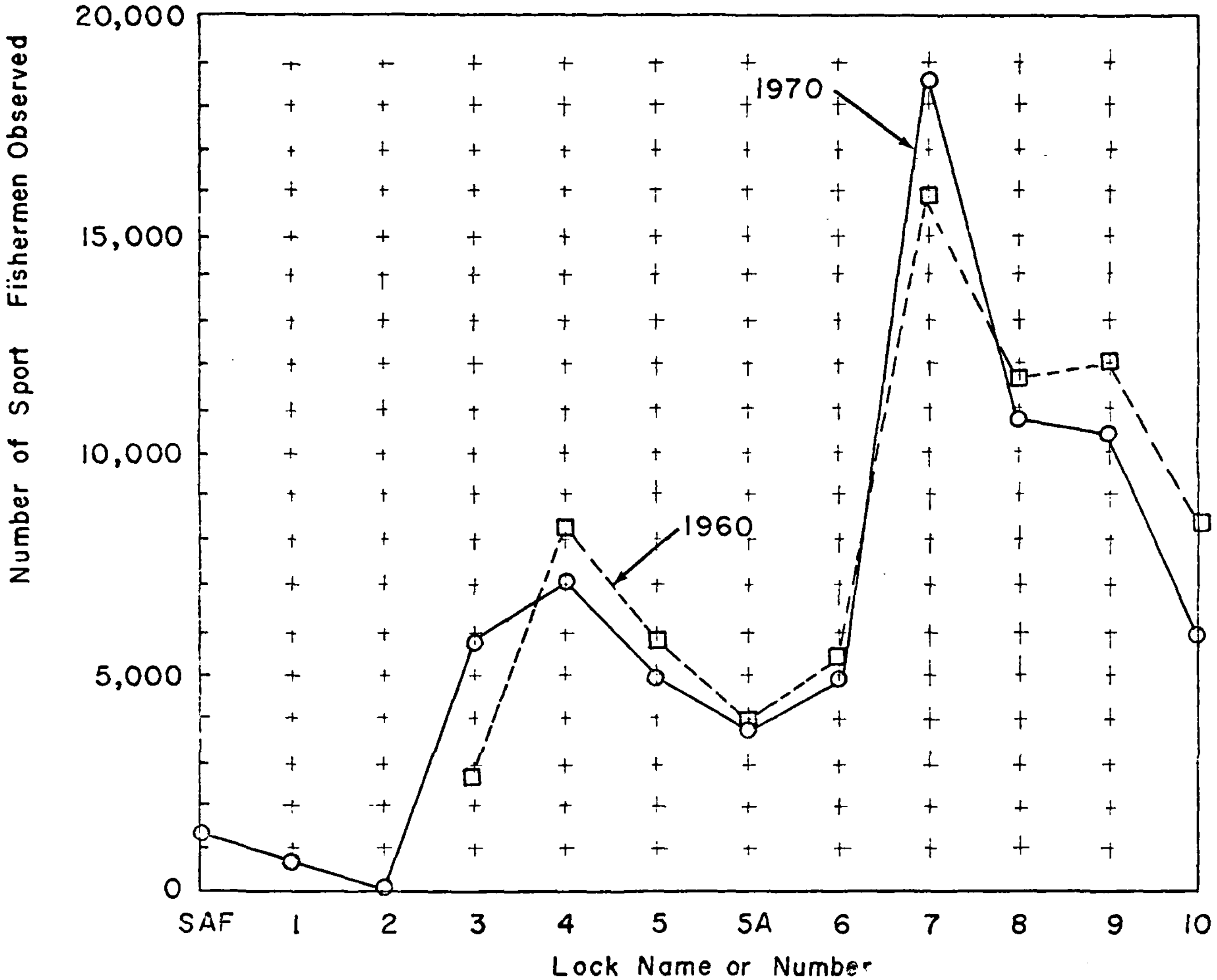


Figure 56. Number of Sport Fishermen Observed in 1960 and 1970
(S.P.D.-NCS, selected years)

Perhaps the major recreational activity in Pool 1 is sightseeing and picnicking. From the vicinity of the campus of the University of Minnesota to Lock and Dam 1,both banks of Pool 1 are largely devoted to narrow strip parks. These parks cover the steep slopes of the bluffs and a small strip of the level tops of the bluffs. They are interlaced with pathways, benches, tables, fireplaces, etc., which encourage recreational walking and picnicking. There are a number of overlooks which open to vistas of the narrow, steep-sided, wooded, river-gorge and the busy river itself.

Future visitation to Pool 1 (and St. Anthony Falls Pools) are projected to be mainly for picnicking and fishing (See Table 38). Future facilities should also accommodate hiking and biking which were observed to be frequent activities. Perhaps a swimming beach should be planned especially for safety reasons because several informal beaches have become popular.

Cultural Considerations

Some historical and contemporary sites exist in the study area. No sites in Pool 1 are known to have been located below the bluffs; thus no site has been affected by operations of the Corps of Engineers.

Table 38. Estimated Probable Future Visitation at Public-Use Sites in Mississippi River - Pool 1 and Upper and Lower St. Anthony Falls Pools

Activity	Base = 1963 (table 5)		1970 = +30 percent (1)		1980 = +81 percent (1)		1990 = +141 percent (1)		2000 = +217 percent (1)	
	Annual	Peak day	Annual	Peak day	Annual	Peak day	Annual	Peak day	Annual	Peak day
Camping	0	0	0	0	0	0	0	0	0	0
Picnicking	6,480	212	8,424	275	11,729	384	11,729	384	11,729	384
Boating	270	4	351	5	489	7	651	9	856	13
Fishing	4,500	72	5,850	94	8,145	130	10,845	174	14,265	228
Water-skiing	90	1	117	1	163	2	217	2	285	3
Swimming	0	0	0	0	0	0	0	0	0	0
TOTAL	11,340	289	14,742	375	20,526	523	23,442	569	27,135	628

(1) Projected visitation is based on preferential development and complete utilization of facilities by 1980 with camping and picnicking remaining constant from 1980 to 2000.

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3. THE ENVIRONMENTAL IMPACT OF THE NINE-FOOT NAVIGATION CHANNEL

INTRODUCTION

Impacts are understood here to be environmental responses to human activities. This study deals mainly with those impacts resulting from the Corps of Engineers' navigation channel project and related activities in Pool 1 of the Mississippi River.

Because little detailed information appears to exist which describes such impacts in Pool 1 the impacts listed below were derived from:

1. field studies in Pool 1 and elsewhere on the Mississippi River during summer, 1973;
2. information from previous studies of Pool 1 which were made for other purposes;
3. information from studies elsewhere on the Mississippi River;
4. basic ecological and socioeconomic principles and processes;
5. personal experience of the investigators.

Field studies during the summer of 1973 extended the data base to provide further information on at least the major impacts.

The Corps' project which produces these impacts includes (a) the presence of Lock and Dam 1 Mississippi River Mile 847.6 and (b) the operation of these structures and the maintenance dredging of the nine-foot channel. Additional impacts arise from (c) navigation by commercial and private vessels of the river and from their attendant facilities, and (d) barge terminals and related facilities. The environmental impacts of this project are the changes brought about in the physical and biological components of natural systems and in changes in the industrial, recreational and cultural components of socioeconomic systems.

NATURAL SYSTEMS

Identification of Impacts

The initial impacts of impoundment and dredging by the Corps of Engineers upon the natural environment in Pool 1 are:

1. formation of a slackwater pool by impounding a reach of the river;
2. increase in bare, erodable soil (spoil banks);
3. increased turbidity due to dredging, spoiling and navigation;
4. increased incentive for developing the floodplain and river banks;
5. moderation of water level changes.

The initial impacts listed above result from Corps' operations and maintenance activities, navigation, barge terminals and related facilities and to pre-project activities (such as snagging and cleaning activities), presented in Tables 39, 40 and 41. From the initial impacts, stem the "secondary" and "subsequent" environmental impacts which are then traced further, if possible, in the discussion section.

It should be noted that the impacts in Pool 1 are not always completely isolated and ascribable to the Corps. This is because these impacts are part of a complex, multi-dimensional web of physical-chemical, biological and socioeconomic interactions. Impacts may also derive partially from other economic and cultural activities and from natural environmental processes acting in the local area as well as in the larger basin.

Discussion of Impacts

Since the Corps already had built Lock and Dam 1 and formed a pool for the six-foot channel project, the increase in depth to nine feet for the present project must have had relatively less impact on the natural environment in Pool 1 than elsewhere. The Pool 1 area is unique, however, because of its close, high bluffs and limited floodplain, and its location in the heart of the Twin Cities.

Table 39. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Maintenance Dredging	1. Increases turbidity.	1. Covers benthos, aquatic plants.	1. Reduces other biota in food web.
		2. Suffocates fish, spawn	
		3. Reduces water quality	
	2. Exposes new, sterile benthic substrate.	1. Loss of benthos.	1. Decreases fish; decreases waterfowl, vegetation, wildlife.
	3. Decreases aesthetics.		
Spoil deposition	1. Loss of terrestrial vegetation due to repeated disruption.	1. Spreads to cover more terrestrial habitat; redeposits in channel, backwaters.	1. Lose vegetation; decrease wildlife. 2. Confines channel. 3. Spreads and creates shallows; less benthos.
		2. Decreases flood capacity.	
	2. Confines channel.	1. Increases water velocity.	1. Decrease river benthos, fish, waterfowl.
		2. Decrease shallow water area.	1. Decrease river benthos, fish, waterfowl.
	3. Increases recreation by providing more sites.	1. Increases aesthetics for some people. 2. Increase disturbance of wildlife.	

Table 39. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems (Continued)

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Spoil deposition (continued)	4. Decrease aesthetics (for some people).	1. Decrease recreation.	
Dam #1	1. Impoundment of river (raised water levels).	1. Flooded dry land.	1. Decreased floodplain. 2. Decreased terrestrial habitat; decreased terrestrial upland biota. 3. Increased shallow-water area; increased benthos, fish habitat in upper end of pool.
		2. Increased depth, slowed current.	1. Decreased flowing-river species of fish, clams. 2. Increased sedimentation, changing bottom type from gravel to sand and mud; decreased benthos. 3. Increased eutrophication; nuisance species. 4. Submerged riffles; decreasing benthos, fish. 5. Increased conversion of remaining floodplain and some blufftop to industry; increasing flood damage; decreasing water quality. 6. Increased rate of sewage degradation; decreased local water quality in Pool 1 area, increased water quality downstream.

Table 39. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems (Continued)

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Dam #1 (continued)			7. Increased ice thickness; decreased aeration and sewage breakdown. 8. Reduced water level fluctuation; improved aesthetics for those who prefer lakes to rivers; improved for motorized craft; ideal conditions for rowing crews and scullers (combined with high valley walls to break the wing); reduced appeal for canoeists and kayak enthusiasts.
	2. Increased current downstream from Dam #1.	1. Increased bank and bottom erosion. 2. Aerated water.	1. Increased fish concentration; increased recreation.
St. Anthony Falls Dam	1. Increases dissolved oxygen in upper reach of Pool 1.	1. Increases benthos.	1. Increases percentage of sport fish; subsequently increasing recreation; also increases food for shorebirds.
		2. Increases percentage of sport fish in upper Pool 1.	

Table 39. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems (Continued)

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
St. Anthony Falls Dam (continued)	2. Decreases in sediment load.	1. Increases water quality in upper reach of Pool 1.	1. Increases quantity and diversity of biota in upper reach of Pool 1.
	3. Barrier to migration of fish and benthic animals.	1. Decreases spawning.	
St. Anthony Falls Lower Lock	1. Surges in flume in upstream end of Pool 1.	1. Increase in bank erosion and bottom scouring in Pool 1.	1. Increased sedimentation downstream, subsequent loss of benthos in Pool 1.
	2. Permit passage of fish.	1. Allows passage of other aquatic life, eg., clams, insect larvae.	
Lock #1	1. Same, in Pool 2.	1. Same, in Pool 2.	1. Same, in Pool 2.
	2. Same, in Pool 2.	1. Same, in Pool 2.	

Table 40. Probable Impacts of Commercial Navigation, and Barge Terminals and Barge Maintenance Facilities on Natural Systems in Pool 1

Activity or Structure	Initial Impact	Secondary Impact	Subsequent Impacts
Navigation	1. Increased turbidity.	1. Decreased aquatic biota.	1. Decrease in wildlife and waterfowl.
	2. Increased (shore) erosion.	1. Increased turbidity.	1. See second and additional impacts above.
		2. Decreased terrestrial habitat.	1. Decreased wildlife.
	3. Increased fumes and effluents adverse to existing biota.	1. Decreased aquatic biota.	1. Decreased waterfowl and wildlife.
		2. Decreased aesthetics.	
	4. Possibility of spills of oil and hazardous materials.		
	5. Increased aesthetic interest.		
	6. Increased noise.		
Barge terminal, fleeting area, dry dock	1. Adverse effluents.	1. Decreased aquatic biota.	1. Decreased waterfowl, furbearers.
	2. Loss of terrestrial habitat.	1. Decreased wildlife.	
	3. Increased noise level.	1. Decreased wildlife.	
	4. Rusty or dark brown hulls.	1. Hazard at night when unmarked.	
		2. Adverse aesthetics.	
Barge cleaning facility	1. Possible adverse effluents.	1. Possible decreased aquatic biota.	1. Possible decreased waterfowl, furbearers.

Table 41. Probable Impacts of Corps Activity and Structures Prior to 1930 Upon Natural Settings in Pool 1

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Removal of snags, wrecks, shoals and sandbars, beginning about 1825	1. Increased turbidity	1. Decreased benthic organisms, fish.	1. Decreased waterfowl, furbearers.
	2. Decreased benthic substrate.		
Headwater reservoirs, beginning in 1880.	1. Moderated water level and current changes.	1. Increased abundance, diversity of aquatic biota.	1. Increased abundance of waterfowl, furbearers.
Extension of 4.5-foot channel to Minneapolis, in 1890.	1. Dredging sandbars, removal of boulders.	1. Decrease substrate.	1. Decrease benthos; decrease fish and wildlife.
		2. Increase turbidity.	1. Decrease benthos; decrease fish and wildlife.
Construction of original Lock and Dam 1, and old Lock and Dam 2, 1894-1907.	1. Increased turbidity.	1. Decreased aquatic biota.	
	2. Loss of aquatic substrate.	1. Decreased aquatic biota.	
	3. Increase water temp.	1. Change in aquatic biota.	
	4. Deepened, slowed river.	1. Loss of flowing-river organisms.	
	5. Decreased terrestrial habitats; lost 13 islands.		

Table 41. Probable Impacts of Corps Activity and Structures Prior to 1930 Upon Natural Settings in Pool 1 (Continued)

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Dredging for 6-foot channel, about 1907.	1. Increased turbidity.	1. Decreased benthos, fish.	
	2. Increased bare area.	1. Decreased benthos, fish. 2. Decreased wildlife.	
Spoil deposition	1. Covered benthic, terrestrial habitat.	1. Decreased bottom organisms, fish; terrestrial vegetation.	1. Increase protection for some waterfowl.
	2. Confines channel.	1. Increases water velocity.	1. Reduces river benthos.
		2. Increases bank erosion.	1. Increases turbidity, sedimentation, loss of benthos.
	3. Increases recreation sites.	1. Increases disturbance of wildlife.	
	4. Decrease aesthetics (for some people).		

Thus, the on-going maintenance of the nine-foot project also may have a greater impact. Environmental impacts of early channel projects as well as the nine-foot project have not been reported-upon previously.

Although atypical compared with downstream pools, some effects of the present project may be similar to those in other pools. Thus, insofar as possible, the impacts described above should be considered in the framework of the whole Mississippi River system and in light of other human developments.

The Mississippi River mainstream is the largest continuous freshwater corridor in the United States. Long recognized for its unique scenic, fish, shellfish, wildlife, recreation and transportation qualities, concern for the future of wildlife and fish in the valley which led to the establishment of the Upper Mississippi River Refuge is still vital today.

Channel Maintenance

The effect of dredging in Pool 1 apparently has not been studied. Compared with other on-going Corps' activities in the Upper and Lower Pools, dredging and spoiling probably have the greatest impact on the natural environment.

Annually an average of over 125,000 cubic yards are dredged from the St. Anthony Falls pools. This amount is only slightly below the average annual volume of the other pools in the Twin Cities area and the remainder of the St. Paul District as well (See Table 42). Because of the length, the dredged volume averages 22,000 cubic yards per mile. This is 38% more than the next highest volume. However, there is no floodplain; thus the spoil is piled higher or further constructs the channel. Although this constricting process increases hydraulic efficiency--thus possibly reducing dredging--it also increases flood levels upstream. Further, more aquatic and terrestrial habitat is lost when the spoil is spread out. When the spoil is piled higher it revegetates less rapidly, if at all; it erodes more easily; and it is aesthetically displeasing.

Table 42. Quantity of Sediment Dredged per Year from the Mississippi River and Navigable Tributaries in the St. Paul Engineers District (Calculated from data from S.P.D.-NCS, 1973)

Pool or Tributary	Average Annual Volume Per Year (in cubic yards)	Average Annual Volume Per Year Per River Mile (in cubic yards)
St. Anthony Falls	23,522	5,470
Pool 1	125,640	22,042
Minnesota River	12,253	834
Pool 2	175,126	5,422
St. Croix River	40,836	1,667
Pool 3	112,187	6,130
Pool 4	487,836	11,062
Pool 5	235,969	16,052
Pool 5A	152,302	15,865
Pool 6	95,371	6,716
Pool 7	150,303	12,738
Pool 8	282,549	12,127
Pool 9	155,000	4,984
Pool 10	94,313	2,875
Total 14 — Total Annual Volume, St. Paul District	2,143,207	

Average Annual Volume per Pool 153,086

Average Annual Volume per Mile 8,856

The effects of dredging may spread beyond the site and last longer than just the dredging period. Dredging creates a sterile area of the river bottom and increases turbidity in the river. Turbidity may be harmful to fish and other aquatic animals, as well as possibly reducing the productivity of aquatic plants on which the aquatic animals ultimately depend. A study of the effects of dredging upon water turbidity revealed that a 3-fold increase in turbidity at the surface and at the bottom occurred 100 feet downstream from the clamshell dredge. While the surface turbidity returned to "normal", the turbidity on the bottom was still nearly double the "normal" nearly a mile downstream from the dredge (Figure 57). The amount of increased turbidity and area affected may be less in Pool 1 even though the same equipment is used, because the dredged sediment in this pool is generally a coarser sand than at the study site in the Minnesota River.

The unstable, unconfined spoil banks usually begin eroding as soon as they are deposited, with the resuspended sediments causing increased turbidity and redeposition downstream. This sediment probably smothers bottom organisms and removes fish habitat (and often requires redredging downstream in the navigation channel).

While the greatest turbidity may persist only as long as dredging proceeds, the recolonization of the bare river bottom may take years to accomplish. Mollusks have been reported to take ten or more years to recolonize a dredged area (Stansbery, 1970).

It seems, therefore, that the effects of dredging adversely affect the natural environment not only on the actual site,but further downstream, and through a longer period of time than at the actual dredging site and time.

Apparently some of the spoil is becoming revegetated. However, most of the spoil lacks natural vegetation because it is too dry. Aesthetic appeal of this reach of the river thus has been impaired. These nonvegetated sites will erode and deposit more sediment in the river which must then be dredged out again.

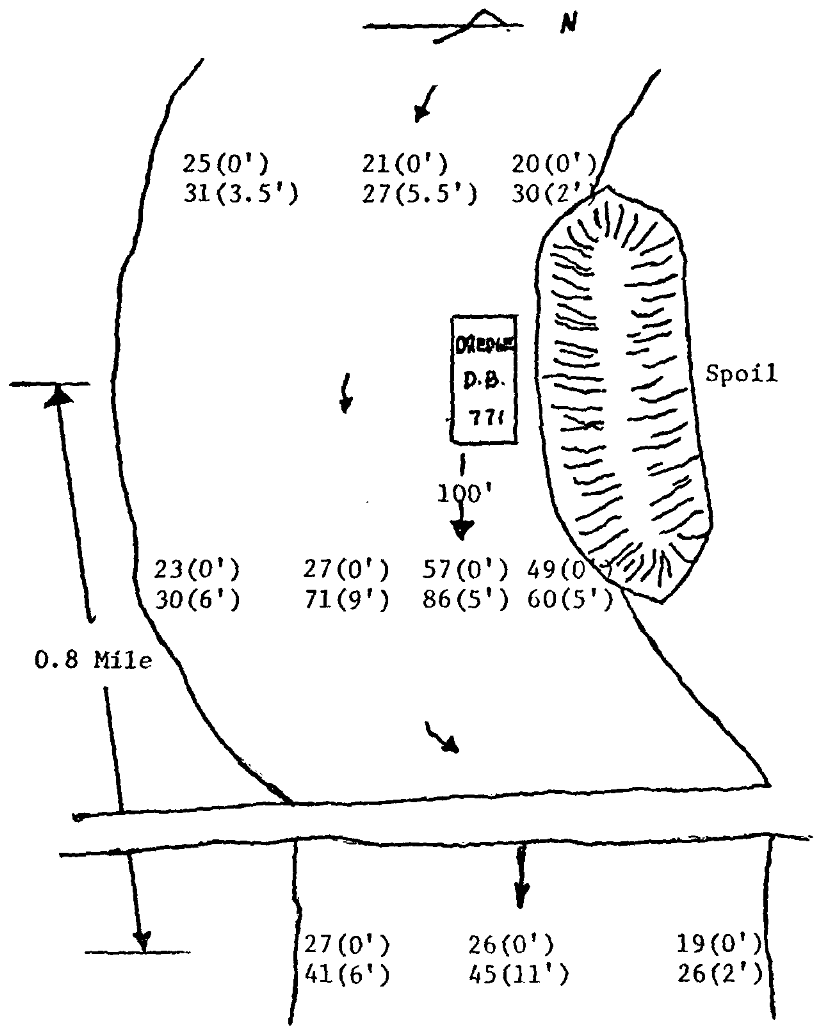

Figure 57. Effect of Clamshell Dredging Upon Turbidity in the Minnesota River, September 25, 1973 Depth in feet in ( ).

Lock and Dam Operation

As mentioned above lock operations may provide a by-pass around the dam to fish and mussels; attendant surges in current may produce some increase in turbidity and bank erosion.

Although they may retard the migration of fish and mussels, dams provide a good means for aerating the water and thus improving conditions for aquatic life.

Navigation Effects

Commercial navigation, barge terminals and other facilities dependent upon the nine-foot channel, may have adverse environmental effects on Pool 1.

The turbidity increases because of resuspension of bottom sediments from propeller turbulence, and by bank erosion due to the energy of the wake, by two to three times within 30 seconds after passing. Even 30 minutes after passing the turbidity may be 1 1/2 times that prior to passage of the tow (Figure 58). The amount may be less in magnitude and duration in Pool 1 because some of the sediments are coarser than the study site in the Minnesota River. Spills and discharges coming from the vessels and barge terminals may be adverse to the environment. The activity of commercial traffic up and down the river provides aesthetic interest to many people, but may also disrupt fish and waterfowl behavior.

Effects of Impoundment

Impoundment of the Mississippi River in the gorge, formed when St. Anthony Falls was receding has converted a large segment of a youthful, wilder river into a quiet reflective pool. A remnant of the river's former energetic surface may be found under the Burlington Northern Bridge,just downstream from the St. Anthony Falls Lock and Dam. The placid waters of Pool 1 provide unmatched facilities for the University of Minnesota and the Minneapolis rowing clubs.

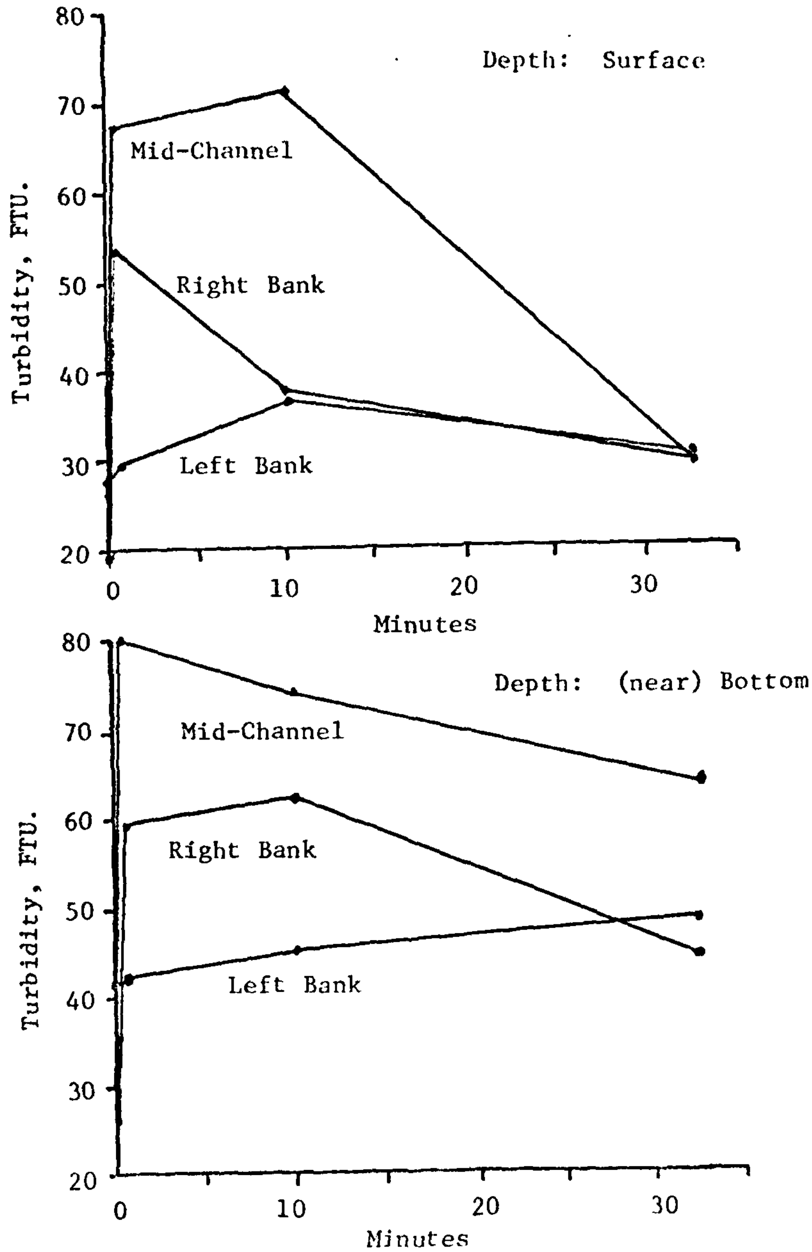

Figure 58. Duration (in minutes) of Increases in Turbidity Due to a Tow Boat on the Minnesota River at Mile 13.3, from the Right Bank to the Left Bank on September 25, 1973.

However, this quiet pool also has the greatest amount of dredging annually per mile than elsewhere in the Twin Cities area and the whole St. Paul District as well. While the spoil banks provide areas for recreation, the spoil is gradually filling in the narrow gorge, altering its aesthetic quality and reducing the river to a narrow channel. Spoil disposal as well as dredging also may be detrimental to the recently reported small mouth bass fishing.

As the spoil erodes, shallow water areas are formed which may provide additional fish and waterfowl habitat. These shallow areas may also be used for beaching small boats.

Except at the heavily-traveled bridges, the large apartment tower near the Ford Bridge, and the tall, clumsy Health Sciences Building at the University, travelers through the gorge can easily forget that they are passing through the heart of a large metropolitan area. As bare spoil banks continue to fill the gorge, and as more apartment and other towers command the skyline, the aesthetic appeal of Pool 1 will decline sharply.

By virtue of converting a free-flowing river to slackwater pools and subsequent sedimentation, impounding the river and maintenance of the channel, along with urbanization, are undoubtedly the most important human activities affecting the river system. By comparison

> ". . . in the non-pooled section of the Mississippi River between Cairo, Illinois, and St. Louis, Missouri, a reach of nearly 200 river miles, there has been a loss of nearly 70 percent of the flowing side channels and approximately 30 percent of the channel surface since the 9-foot project began. These losses are directly due to the construction of emergent wing dams and closing structures, in combination with dredging. This section constitutes nearly one fourth of the total Upper Mississippi River reach committed to a 9-foot navigation channel (Vogtman, 1973)."

This serves to emphasize the uniqueness of the remaining riverine habitats farther upstream, particularly Pool 1, as well as to suggest what might eventually happen in this reach.

Human impact on river valley ecosystems developed as the river grew in importance as a trade route. In the nineteenth century, river transportation, which was important earlier in the fur trade, intensified as the land was plowed, the forests lumbered, and cities flourished. These alterations of the watershed probably yielded greater runoff carrying more sediment and nutrients to the river. Water levels may have changed more drastically, leaving broad areas of exposed bottom such as at the head of the present Pool 1 compared with the present pools which now remain full from bank to bank. These changes probably led to greater bank erosion, increased size and number of sandbars and snags, and cutting off and filling in of backwaters.

The increasing importance of the Mississippi River transportation to the economy of the Midwest led Congress to direct the Corps of Engineers to develop the river for commercial navigation. Initially, impacts were limited to loss of substrate through the removal of snags and boulders. Later, channelization by wing and closing dams and by dredging brought larger-scale impacts.

Some organisms probably benefited from impoundment while others probably suffered. Perhaps northern pike, sunfish and carp increased. However, the skipjack herring, Ohio shad and blue sucker have been eliminated from the river.

Impounding the river slowed the current, resulting in deposition of sand, silt and organic matter burying the rocks and gravel of the free-flowing river bottom. The increase in water level eventually eliminated 13 islands, totaling 73 acres (See Figure 59 and Table 5 in Section 1). Some of these islands now are shallow areas, some were dredged and others reside below spoil.

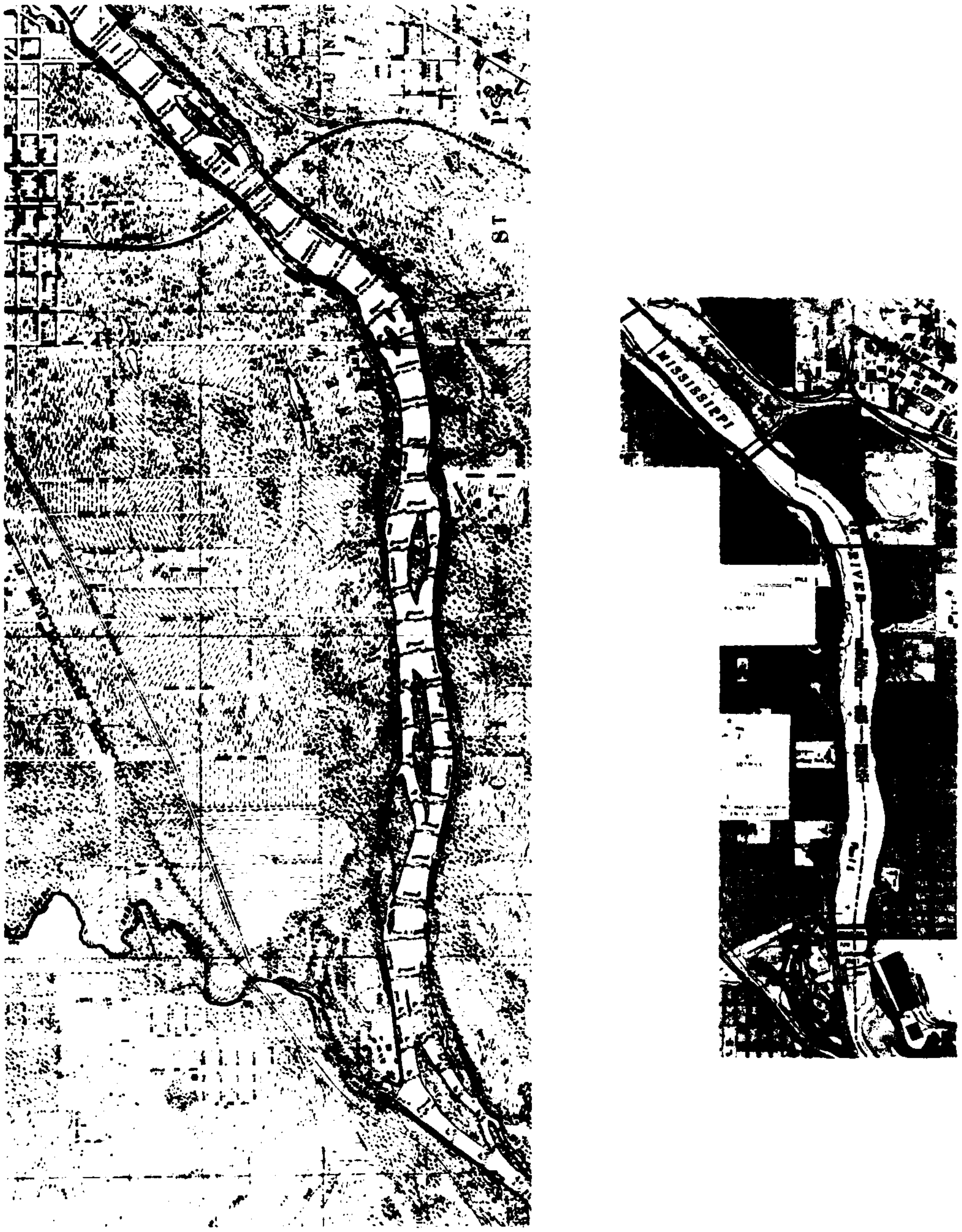

Figure 59. Comparison of 1895 (MRC, 1985) with 1967 (USGS, 1967) Environmental Setting in in Pool 1. Note increased water surface, lack of islands, appearance of sandy (spoil) areas, and urbanization.

Slowing of a rapid, free-flowing river into a slackwater pool, a moderate pollutional load and constant dredging up and thus killing of the clams has probably resulted in a severe reduction of the mollusk community.

Apparently most mollusks require a "lively current", and a migrating fish community in order to disperse and maintain productivity. The migration of fish is prevented (or discouraged) by dams (Ortmann, 1909), although navigation locks may occasionally provide a means to bypass this barrier. Grant found 27 species of mussels at Fort Snelling in the 1880's, where more recently only 13 species were located (Dawley, 1947). This reduction in diversity may be the result of the combination of urbanization and the disruptions of the nine-foot channel project.

SOCIOECONOMIC SYSTEMS

The impacts of the Corps of Engineers' nine-foot channel project upon components of the socioeconomic system bordering Pool 1 are identified below and then discussed in detail. The socioeconomic impacts originate from the Corps' operation and maintenance of Lock and Dam 1 and from maintenance dredging of Pool 1, as well as from the Lock and Dam and maintenance dredging elsewhere in the Mississippi River. Thus these project features produce a commercially profitable navigation channel extending from Minneapolis 857 miles to Cairo, Illinois.

Identification of Impacts

The impacts of the river-borne commerce and the Corps' project features which provide the channel may be divided into industrial, recreational and cultural effects. At present it is possible only to estimate these impacts by using the numbers of facilities and vessels, and estimating the number of people involved. However, information is as yet unavailable on the dollar value of these impacts.

Industrial Impacts

The principal industrial impacts are:

1. Barge transportation on the Upper Mississippi that leads to:
   a. An increase in commercial docks on the River and attendant employment,
   b. Location of industrial plants along the River whose raw materials or products lend themselves to shipment by barge; this contributes direct employment in these plants and indirect employment in firms --
      1) providing goods or services as inputs to the barge-oriented plants, or
      2) using the outputs of these plants or raw materials for their own operations,
      3) reducing the recreation area and access, and
      4) reducing aesthetic appeal of the gorge.
   c. A decline in the quality and increased turbidity of water in some portions of the Upper Mississippi River due to --
      1) effluents produced by barge-oriented plants, and
      2) turbidity caused mainly by towboat movement
2. Additional employment due to the operation of the Locks and Dams.
3. Decline in recreational opportunities on and alongside the River due to:
   a. Increase in barge activity in pools and locks,
   b. Loss of potential ramp sites due to industrial development of riverbank property,
   c. Loss of potential marina sites due to straightening and narrowing of the river, and joining islands to the banks,
   d. Decline in aesthetic appeal of riverscape.

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-foot channel and its associated locks and dams by

the Corps of Engineers are an increase in the number of industrial plants and commercial docks along the River with their associated employment, and the employment in lock and dam operation. The detrimental effects are a decline in water quality due to river barges and the related industrial plants along the River, and a decline in opportunities for recreation on and beside the River.

Recreational Impacts

The principal recreational impacts are:

1. A potential increase in recreational boating due to stable, navigable water levels which should lead directly to more marinas -- and their accompanying employment in other pools;
2. A potential increase in bird watching and fishing due to an increase in --
    a. Waterfowl habitat, and
    b. Fish spawning areas resulting from rising water levels.
3. An increase in sightseeing visitors to Lock and Dam 1 and to the gorge as a result of the spoil piles.

The effects cited above are positive except for those from increased industrial activity (barge traffic and industrial plants) that may reduce boating and fishing.

Cultural Impacts

No archaeological or historical sites of cultural significance in Pool 1 are known to have been affected by Corps' operations. A unique cultural feature, the Minneapolis Centennial Showboat, is located at the University of Minnesota (Mile 852).

Discussion of Impacts

The industrial and recreational impacts identified above are examined in detail in the following three sections.

Industrial Activities

The industrial impact of the activities of the Corps of Engineers on the Mississippi River in the St. Paul District can be measured mainly by two major elements. They are:

1. The number of commercial docks for the transfer of cargo and storage facilities;
2. The number of vessels and the tonnages on the waterway.

The industrial impacts due to the Corps' project in Pool 1 appear relatively minor compared with Pool 2 because of the few terminals and vessels. The limited floodplain area available for recreation and the unique aesthetic quality of the gorge, contrastingvertical cliffs and horizontal water, suggests that perhaps the barge terminals and related facilities in Pool 1 may have a significant impact. This impact will be substantially reduced when the present relocation of three of the terminals to the St. Anthony Falls Upper Pool is complete.

The relocation of the Minneapolis Municipal Terminal means that the industrial impact will be primarily the number of vessels and size of the tows on the river which are passing through to and from the St. Anthony Falls pools.

The sand dredged from Pool 1, which averages 125,000 cubic yards annually, could become a significant economic impact if a market could be developed. This positive impact also would greatly reduce the adverse impacts upon the natural environment caused by spoiling of the dredged sediment.

Barge Activity. The greatest and most obvious impact of the activities of the Corps of Engineers in Pool 1 has been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g. locks and dams, and the four commercial docks and terminals) on the shores and the barge tows moving along the river. Pool 1 has been the origin or terminal for a small amount of the commodities that move in barges along the Upper Mississippi River until 1909. But more importantly it serves as a water link between important commodity terminals upstream in the St. Anthony Falls pools and downstream from it.

Figures 60 and 61 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Although receipts still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three decades indicates the great impact of the river on the regional economy.

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMRCBS, Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about triple from 1964 to 2000.

It is noteworthy that receipts into the St. Paul District have always exceeded shipments. In earlier years this imbalance was often extreme(e.g., 1953 receipts = 3,052,144 tons, shipments = 334,233 tons). Recently,however, the ratio has been around 2:1. Inasmuch as grains and soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound due to crop conditions and storage facilities, foreign sales, and competing forms of transportation.

Data are not available on the tonnage of cargo originating, terminating, or passing through the St. Paul District. However, some comparative idea of shipping activity can be gained from the following information. Vessel traffic

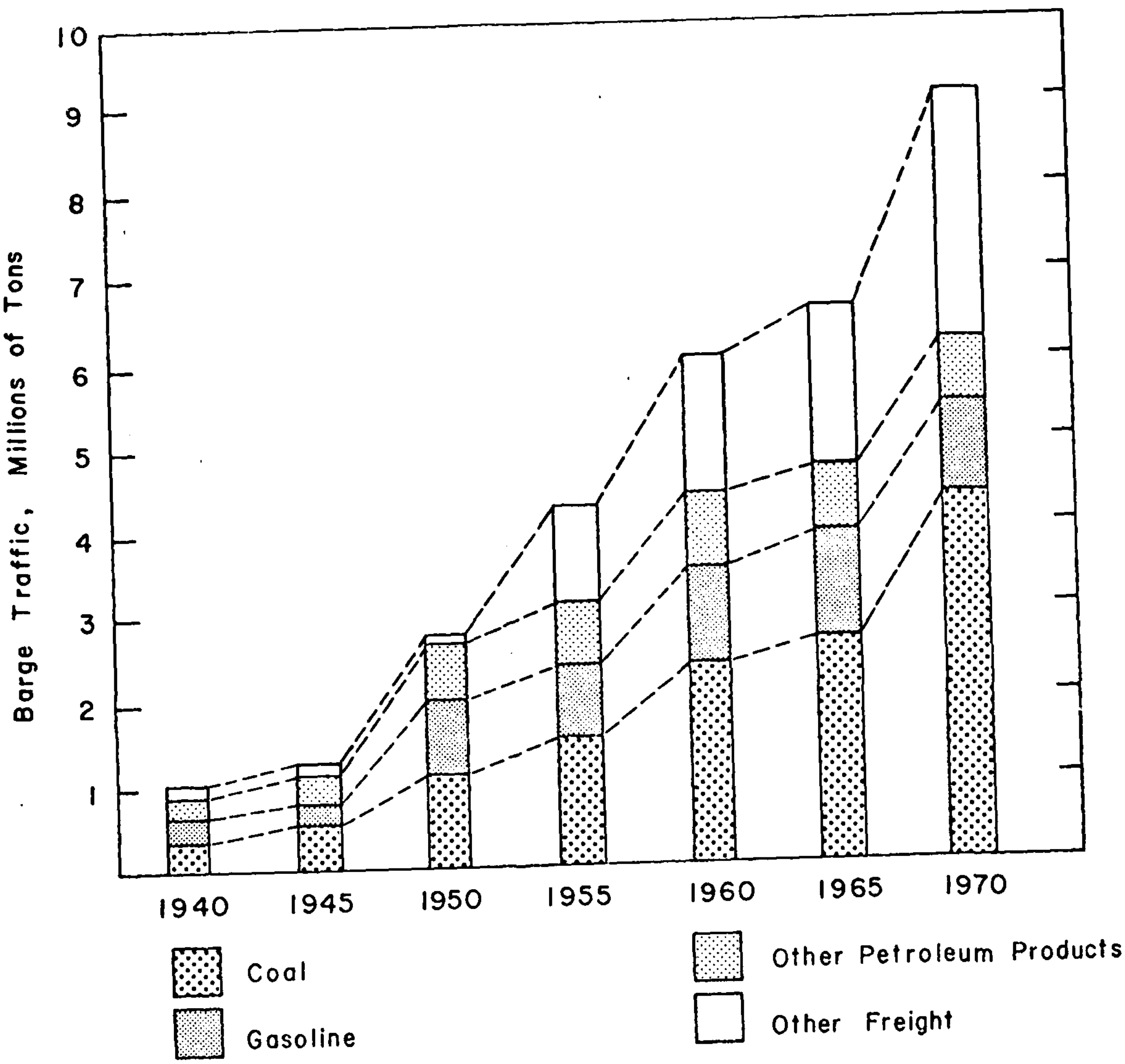

Figure 60. Receipts of Major Commodities -- All Ports, St. Paul District (Based on data from U.S. Army Corps of Engineers, St. Paul District)

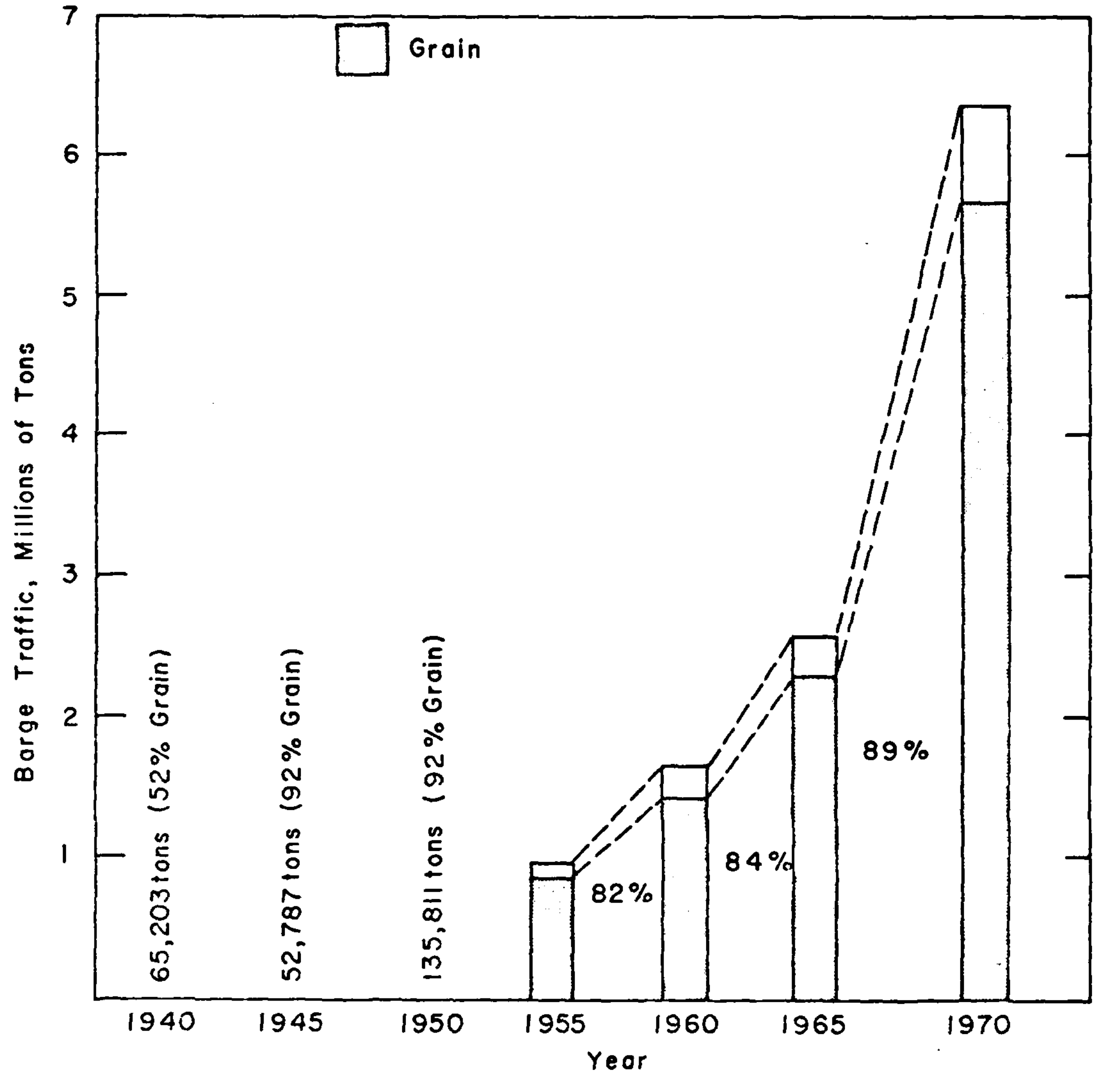

Figure 61. Shipments Out of the St. Paul District
(S.P.D.-NCS, Selected years)

measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (Tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

Detailed data on the amounts of commodities originating in Pool 1 or destined for it are not available. However, analysis of commercial and industrial facilities adjacent to the pool suggests that the major commodities originating or terminating in the pool are grain, petroleum products, coal, and steel.

Statistics on the numbers of vessels originating, terminating, or passing through Pool 1 are not available directly. However, some comparative idea of barge activity can be gained from studying the commercial lockages through Lock 1 and the Lock at the Lower St. Anthony Falls -- the locks at either end of Pool 1 -- which are shown in Table 43. From 1960 to 1972 commercial lockages through Lock 1 increased by 100 percent and those through Lower St. Anthony Falls increased from only 71 in 1960 to 2,072 in 1972.

Commercial Dock Facilities. Firms that depend heavily on the river often maintain riverside facilities. Pool 1 presently contains four commercial docks and terminals, including one that is devoted exclusively to petoleum products, one only to grain, and two to coal.

Behind these docks are factories and/or storage facilities that are dependent upon them. Thus, the ramifications of river navigation reach deeply into the entire economy of the region surrounding Pool 1 and indeed throughout the whole upper Mississippi region. Employment directly and in-

Table 43. Commercial Lockages in Pool 1
1960-1972 (S.P.D.-NCS, selected years).

Year	Commercial Lockages Through... Lock 1	Lock LSAF[a]
1960	1,082	71
1961	1,323	317
1962	995	69
1963	1,367	294
1964	1,688	523
1965	1,571	1,047
1966	1,703	1,199
1967	1,560	1,096
1968	1,748	1,419
1969	1,949	1,743
1970	1,914	1,694
1971	1,765	1,442
1972	2,193	2,072

[a]Lower St. Anthony Falls Lock

directly connected to these industries forms a small though significant percentage of the regional work force.

From an economic point of view most of the effects of the activities of the Corps of Engineers are beneficial. Ultimately the benefits of economic activity have to be measured in terms of providing livelihood to human beings. Employment generated by the availability of waterborne transport to Pool 1 includes both workers directly connected with the river itself and a far larger number of those whose livelihood is less directly dependent on water shipping. In the first category is included employment by the Corps of Engineers itself, workers on docks and shoreside facilities, and those working on the vessels themselves. The second category consists of those whose livelihood is gained by either utilizing the products brought into Pool 1 by waterborne carriers or who process goods shipped by water. Included in this category are those who supply goods and services to those directly involved with water shipping on the Upper Mississippi.

The total employment involved either directly or indirectly with all commercial operations on the river is not known. The Corps of Engineers itself has some 150 persons who are concerned with lock and dam operations. In addition to this the dredge "Thompson" has approximately 65 crew members. U. S. Department of Commerce data on employment on the Upper Mississippi are deficient as well. These data are collected for mid-March, a period when water traffic in the St. Paul District is almost completely inactive and seasonal lay-offs are in effect. Further, these data are aggregated in a way designed to prevent isolation and identification of particular firms. This also has the effect of preventing identification of employment or other economic activity in particular pools or even of particular waterways. However, some estimates of employment can be made. In mid-March of 1971 8,632 persons in the U. S. were employed in River and Canal Transport. This figure does not include warehousing or persons employed by firms where the SIC classification lies outside of transportation, even though they themselves may be working exclusively on the river. The same data show 556 persons in Minnesota as a whole who work in the field of water transport. This, however, includes the Great Lakes as well as the Upper Mississippi. Some of these people are employed by private dredging firms whose existence is dependent upon the work of the Corps.

A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least-cost alternatives of between 4.0 and 5.4 mills per ton-mile.* It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, and move through Pool 1 on river barges.

*Source: Upper Mississippi River Comprehensive Basin Study. Appendix J, p. 90.

The socioeconomic impact of the physical effects of navigation cannot be measured precisely because of the inability to isolate single factors from a wide range of potential ones. Dredging and the movement of tugs and barges does increase water turbidity to which must be added pollution from barge spillage, washing and loss while loading or unloading. Yet this pollution is small relative to the load placed in the river from other sources. These impacts may have economic effects on commercial and sport fishing, which are discussed below.

Commercial Fishing. There is no known commercial fishing in Pool 1 due to the lack of habitat and intensive industrial and other uses of the river water. Pollution is significant and appears to have inhibited fish spawning and growth.

Recreational Impacts

Recreational impacts in Pool 1 may be divided into boating activities and related facilities, sport fishing, sightseeing and picnicking.

Boating Activities and Related Facilities. For Pool 1 the best available measures of pleasure boating activity are records of pleasure boats locking through Lower SAF and Lock 1 -- the locks at each end of the pool. These data -- along with the total pleasure-boat lockages through these two locks -- are shown in Table 44 for the years 1960 to 1972. The table shows sharp increases in pleasure craft locking through both Lock 1 (from about 1,300 in 1960 to about 2,800 in 1972) and Lower St. Anthony Falls (from none in 1960 to 1,455 in 1972) during the period. The table also shows an accompanying increase in the number of pleasure-boat lockages during the period. Further increases are expected as water quality improves, recreation areas become available at Nicollet and Boom Islands and simply as the Twin Cities population grows. The present fuel shortage reducing long trips to other waters will help to increase the number of boats also.

A few physical facilities have been developed in Pool 1 that exist mainly to serve boaters using the pool. These include:

Table 44. Measures of Boating Activity in Pool 1, 1960-1972 (S.P.D.-NCS, selected years)

Year	Pleasure Boats Through...		Pleasure-Boat Lockages Through...	
	Lock 1	Lock LSAF[a]	Lock 1	Lock LSAF[a]
1960	1,278	0	708	0
1961	1,211	10	838	10
1962	959	1	623	1
1963	1,427	5	856	5
1964	1,890	887	1,155	679
1965	1,121	402	743	208
1966	1,677	809	1,064	581
1967	2,088	1,024	1,221	732
1968	2,193	1,218	1,422	881
1969	2,415	1,134	1,405	769
1970	2,960	1,482	1,861	1,010
1971	3,455	1,936	1,783	1,226
1972	2,798	1,455	1,568	926

[a] Lower Saint Anthony Falls Lock

Facility	Number
Small boat harbors, marinas, boat clubs	1
Recreational sites with ramps	1

Both of these facilities result from Corps' operations on the River that contributed the channel and stable water levels, although neither are owned or maintained by the Corps.

Other recreational sites adjacent to Pool 1 are not directly affected by Corps' operations.

Sport Fishing. Although precise data on sport fishing are not available, attendants at each lock and dam make daily observations at 3:00 p.m. each day throughout the year of the number of sport fishermen observed from their work location. However, a considerable amount of fishing occurs also along the riverbank although there are no figures presently to demonstrate this. Annual data for the most recent years for which these records are available appear in Table 45. The table shows a wide variation in sport fishermen observed from Lock and Dam 1 since 1963. Because most sport fishermen observed from a lock and dam are downstream from the dam, most of the fishermen seen from Lock and Dam 1 are in Pool 2. Fishermen in Pool 1 -- as seen from Lower St. Anthony Falls, show no noticeable pattern for the available data. Sport fishing in Pool 1 occurs mainly just below Lower St. Anthony Falls to avoid the more polluted downstream areas.

Sport fishing will increase in popularity because of a larger human population, for instance as part of the planned 30,000 population for the Cedar-Riverside Development, of improved water quality, thus more fish, and of greater awareness of the resource among anglers.

Table 45. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites at Both Ends of Pool 1 on the Upper Mississippi River, 1960 to 1970 (UMRCC, selected years)

Year	Lock and Dam SAF	Lock and Dam 1
1960	Not Available	Not Available
1961	Not Available	Not Available
1962	Not Available	Not Available
1963	Not Available	Not Available
1964	2,117	1,184
1965	Not Available	Not Available
1966	Not Available	Not Available
1967	963	1,108
1968	1,162	1,194
1969	1,344	1,428
1970	1,281	635

Note: Counts are made once each day at 3:00 p.m.

Recreational visitation in Pool 1 is difficult to estimate since long strip parks border much of the lower pool. These parks are open along their entire length to use by residents in the vicinity as well as hikers and visitors arriving by car and bus.

Cultural Impacts

The stable water levels of Pool 1 combined with a safe navigational channel makes it possible to maintain the Minneapolis Centennial Showboat near the University of Minnesota and downtown Minneapolis.

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4. ANY ADVERSE ENVIRONMENTAL EFFECTS WHICH COULD NOT BE AVOIDED AS THE PROJECT WAS IMPLEMENTED

Because the nine-foot channel project resulted in deepening of an existing slackwater pool, the impacts of the present project were probably fewer than in other pools. However, the effects of continuing maintenance dredging may be greater by virtue of the limited area of floodplain and shallow-water habitats in the unique gorge, and the location of the gorge in an area of high recreational demand.

Pre-project impoundment lost 70 acres of islands; the nine-foot channel project eliminated the last acre of island. The deepening of Pool 1 for the nine-foot channel probably moved the head of the pool upstream. Thus, some flowing-river organisms may have decreased in abundance.

Increase in pool elevation also inundated some of the terrestrial habitat along the bluuf slopes. While the area of this dry land was probably small compared with that of downstream pools, the area of natural terrestrial habitat in the gorge was considerably less. Thus, the effect of this flooding may be as great as it was in the downstream pools.

The large amount of sediment dredged annually per mile from Pool 1 suggests that the effects of dredging on aquatic ecosystems may be more intensive than in other pools in the area. This may be especially true because the sediment is actually dredged twice (see Section 1).

Field studies of clamshell dredging of fine sediment show that turbidity is considerably increased nearly a mile downstream from a Minnesota River dredging site. In Pool 1, although this effect may not be as extensive because the sediments are somewhat coarser, the annual volume dredged per mile is more than 40 times that of the Minnesota River. This turbidity has adverse effects upon fish and bottom organisms. Furthermore, it has been reported that dredged river bottom may take ten or more years before the clams return.

Spoil sites take a similar length of time, depending at least upon soil moisture which is a function of the height of the spoil pile. Presently there are nearly 46 acres of spoil, most of it bare, erodable soil.

Spoil deposition may have a greater effect than in the downstream pools because there is very little floodplain in Pool 1. Large spoil banks are accumulating the narrow gorge, hastening its filling. These spoil banks vegetate rather slowly, especially because of reuse of the sites, making them higher and drier. This results in further smothering of the benthos and reducing fish habitat.

At present, it is not known what proportion of the sediments originate from upstream, and what erodes from the spoil banks in Pool 1. As the spoil fills in the gorge, the channel narrows, probably becoming a representative of the channelization occurring downstream and in St. Anthony Falls. Because of its small size and large amount of sediment, the gorge may be filled in more rapidly. Thus, the probably considerable aesthetic appeal of the present gorge will be reduced. The fishing would probably decline, as would the canoeing, crew rowing and sculling, and motor boating.

Although it may be questioned whether the Washington Avenue Terminal with its unaesthetic piles of coal and pavement was "avoidable" or not, it intrudes on the view of the river shared by thousands of persons every day on the Minneapolis campus of the University of Minnesota.

Commercial navigation increases the turbidity of the river and contributes to bank erosion. At the same time, it also may detract from the aesthetic quality. Discharges and spills from vessels and barge terminals would also have a detrimental effect, particularly on the aquatic environment. However, studies are needed to determine the nature and extent of adverse effects of these effluents.

Other aspects of the nine-foot channel project possibly have relatively minor adverse effects upon the natural environment of St. Anthony Falls. Discharge from lock operations and turbulence form the dam spillway may cause some increased riverbed and bank scour, and thus downstream turbidity and sedimentation.

5. ALTERNATIVES TO THE PRESENT OPERATIONS AND MAINTENANCE ACTIVITIES AND FACILITIES

Several alternative methods of operating and maintaining the facilities and channel are possible. The large amount of sediment dredged from the channel in Pool 1 and the high aesthetic appeal of the gorge directs attention particularly to the alternatives for channel maintenance.

Channel Maintenance

The first consideration should be the problem of spoil deposition in Pool 1. The lack of room to continue spoiling in the gorge means one or several environmentally less sensitive sites located elsewhere, especially to be reused where it will not find its way quickly back to Pool 1.

Several alternatives exist where the spoil could be deposited and available for reuse. Within Pool 1 and with slight modification, the spoil could be accumulated at the Minneapolis municipal terminal. Another possible site is the downstream edge of the area known as the "University Flats". Next year, when the University's lease of the flats is to be renewed, the Park Board should retain several acres (which may have been an old spoil site) for spoil deposition. An access road is available. This spoil site could also be used as a recreation area, for picnicking and sightseeing. Proper screening with native vegetation of both spoil sites would reduce adverse effects upon aesthetics.

Probably the best alternative spoil site would be a barge terminal already handling sand and gravel. This site would have the necessary equipment to handle barged spoil and provide ready access to potential markets.

A preliminary study by the Bureau of Sport Fisheries and Wildlife, and a comparison of Pool 1 sand with commercially available sand (Figure 62) suggests that a potential market exists for Pool 1 spoil.

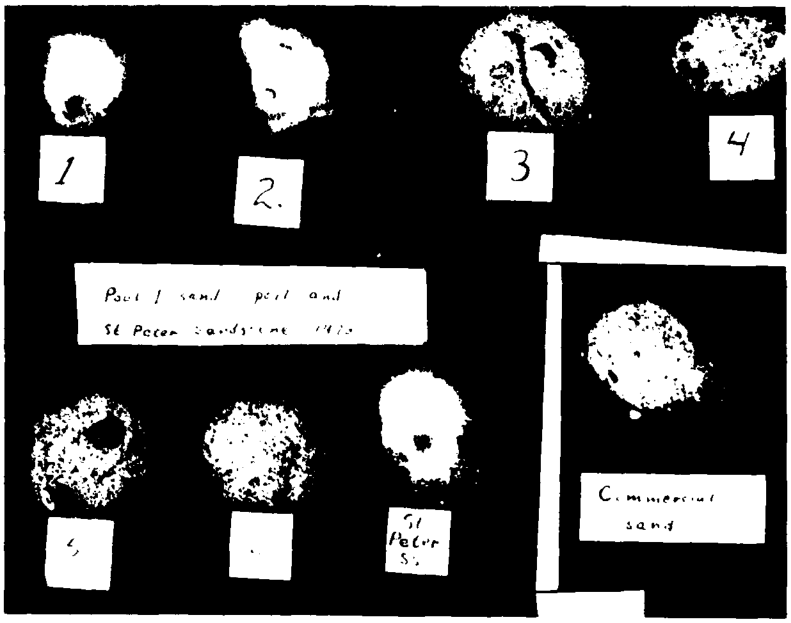

Figure 62. Comparison of Sand from Several Spoil Sites with Commercial Sand (Gudmundson and Senechal, 1973)

Secondly, a small hydraulic dredge should be used, which would reduce the turbidity. Water running off from the newly deposited spoil should be held in a settling basin, then discharged when its turbidity matches that of the river.

Thirdly, the spoil sites which are present could become aesthetically more appealing and environmentally less damaging if efforts were made to revegetate the spoil. Keeping contours low would spread revegetation of the spoil because the roots would be closer to the water level. Alternatively, by reducing the drying of the sand on higher spoil piles with some cover such as a layer of wood chips or irrigation and by reseeding, erosion could be reduced, vegetation increased, thus increasing wildlife. Riprapping the spoil slopes exposed to the current with large blocks also would retard return of

this sediment to the river. Floating log booms anchored parallel to the spoil banks would reduce displacement of the riprapping during the spring ice breakup. Fish and waterfowl habitat also would be improved.

Lock Operation

The auxiliary (riverward) lock should be placed into operation as soon as possible to facilitate passage of pleasure craft, which otherwise must wait for long periods of time for commercial traffic.

Dam Operation

Dam 1 presently is an overflow dam: water passes over only at the crest or through the hydroelectric plant. Thus, sediments are not carried downstrea during high water, as is the case at most of the other dams. Dam 1 should be modified with tainter gates so that the discharge of Pool 1 could, at times, be shifted to the bottom of the pool. This probably would reduce the heavy dredging load this pool requires. This sediment might then accumulate at the St. Paul Barge Terminal, where fish, wilflife, and recreation resources would be less affected. A large barge terminal is located nearby, and it handles sand and gravel. In addition, or at least in lieu of modifying the dam, the lock gates could be modified so that they can also discharge from the bottom of the pool during flood water.

6. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Establishment of the nine-foot channel in Pool 1 brought economic and recreational benefits to local citizens, and probably to some plants and other animals. However, the facilities and operation and maintenance activities have resulted in the alteration of a relatively rare geomorphic feature--a river gorge--and loss of some of its productive natural habitat. Also, the navigation channel has induced the conversion of other natural habitat to urban development.

SHORT-TERM USES

During the life of the project, the growth of river transportation has and will benefit segments of the economy. River-related jobs and businesses may help forge a broader-based economy upon which to develop future economic growth. Recreation and its economic benefits which come from the project may have a wider appeal and facilitate more use of the gorge than the open river may have.

ENHANCEMENT AND MAINTENANCE OF LONG-TERM PRODUCTIVITY

Development of commercial navigation on the Mississippi River in Pool 1 may have benefitted man's long-term economic growth, but also may have altered or reduced natural productivity, although specific information is lacking. The navigation channel resulted in increased water depth, dredging of the river bottom and spoiling on the banks, and construction of navigation facilities. It also stimulated development of commercial, industrial and residential areas. Natural habitats have been altered by the changes brought about by navigation, such as reduced riffle-communities, decreased shallow-water communities, and decreased pollution-sensitive organisms.

As sedimentation and dredge spoiling continue over a long period of time, the inundated portion of the gorge will be buried and the pool reduced to a narrow channel. Thus, some aesthetic and recreational benefits have been and will continue to be lost. This loss may be partially offset by the creation of additional terrestrial habitat which possibly could provide a larger refuge for wildlife--and, in fact, for human beings--and greater accessibility to the remaining gorge.

Terrestrial habitat has been lost also as a result of construction of the locks and dam and the barge terminals. These terminals probably encouraged construction along the river of other facilities not directly connected with navigation. The increased run-off from developed areas such as these and from other bare-soil areas increases erosion and further decreases biotic productivity in Pool 1.

Creation and maintenance of the channel probably has disturbed the natural river habitats on and near the channel sufficiently to reduce biotic productivity. A single dredging or spoiling of a site requires ten or more years to be repopulated. Continued disturbance possibly may alter the physical environment to sufficiently extend this time.

Alternative land-use and maintenance practices could conceivably shorten the time necessary for repopulation of a site and may begin a return of the biotic productivity. Set-back of the businesses and terminals, except for the actual loading-unloading facilities, and a central spoil disposal site could result in a green along both banks. These and other erosion and sedimentation control measures probably could significantly reduce the adverse effects of the nine-foot navigation project and related activities on the enhancement and maintenance of the long-term productivity in Pool 1.

Table 46. First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-foot Channel in Pool 1

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Corps Operations	Lock and dam (L/D) operation	1. L/D employment 2. Stable water levels	1. Cost of L/D operation 2. Sedimentation behind dams and at head of flatwater pool
	Dredging Operations	1. Dredging employment 2. Nine-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat because of improper dredge spoil placement.
Industrial	Barge operation	1. Barge employment 2. Low-cost water transportation 3. Energy saving compared to alternate transportation modes 4. Decrease in air pollution compared to other modes.	1. Increased river turbidity 2. River pollution from oil and gasoline from barges 3. Hazard to small craft
	Commercial Dock	1. Dock employment 2. Attraction of barge-transportation-oriented firms that provide local employment	1. Increased river pollution from industrial activities along shore 2. Loss of riverfront property for recreational use
Recreational	Boating Activity	1. Increased safety of deeper channel for boaters 2. Provided relatively quiet water which is excellent for rowing clubs.	1. Decline in aesthetic appeal of riverscape
	Sport Fishing	1. Initially increased habitat for fish	1. Increased sedimentation in fish habitat 2. Hazard of wing dams and barges

Table 46. **First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel** in Pool 1 (Continued)

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Recreational (cont.)	Bird-watching	1. Initially increase habitat for waterfowl	1. Decreased waterfowl habitat from improper dredge spoil placement 2. Decrease in songbird habitat with removal of trees and brush, and joining of islands for industrial usage
	Sightseeing, picnicking, swimming	1. Increased number of potential swimming areas.	1. Decreased opportunities for miscellaneous recreational activities 2. River pollution from industrial and barge operation 3. Decrease in aesthetic appeal of river
Cultural	Contemporary	1. Provided channel so that the Centennial Showboat can be docked at the University of Minnesota "River Flats".	

Resource Implications for Socioeconomic Activities

The major resource implications of continuing to operate and maintain the nine-foot channel in the St. Paul District are summarized in Table 46. Resource implications; *i.e.*, the costs and benefits of the project, for the industrial, recreational and cultural components of the socioeconomic system are discussed in sequence below.

Corps' Operations

The major first-order direct benefits associated with lock and dam operation and dredging operations are identified in Table 46. These include employment in lock and dam and dredging operations, maintenance of relatively stable water levels in each pool, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus, about 225 people derive jobs and income directly from the Corps' operations. The annual direct cost to taxpayers for lock and dam operations is $2,601,000 (FY 1970), and for dredging operations is $1,200,000. Specific environmental costs of the stable water levels and the nine-foot channel in Pool 1 are an increase in sedimentation behind the dam and a reduction in fish and waterfowl habitat caused by improper dredge spoil placement. Implications of these costs are discussed later in the recreation section.

Industrial Activities

As summarized in Table 46, the major direct impacts of the Corps' operations on industrial activities are barge operations and commercial dock operations. Table 46 notes that there are employment implications for each activity, but the benefits must be balanced against accompanying increases in sedimentation, turbidity, and possibly other pollution in the river.

Of special importance in the current energy crisis are the answers to two questions that relate to barge transportation: How efficient is barge transportation compared with other modes of transportation with respect to:

1. Energy use?
2. Air pollution?

Because the answers have major resource allocation implications for the Upper Mississippi River, these two questions are analyzed below in some detail. In addition, savings in transportation costs caused by barge movements are discussed.

<u>Barge Transportation and Energy Use.</u> Efficient energy use is particularly important because of the present (and probably continuing) energy crisis. Efficiency also affects levels of air pollution.

At present, transportation uses about 25 percent of the total United States energy budget for motive power alone. This use has been increasing at an average annual rate of about four percent per year.

In comparing the efficiency of energy use between various transportation modes the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) consumed when one ton of freight is carried one mile (one ton-mile). The following table compares the energy intensiveness of various modes of freight transportation (Mooz, 1973):

Transportation Mode	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air cargo	63,000	126.

It is apparent from the above table that waterways are more efficient than any other mode of freight transportation. Therefore, under conditions of restricted availability of petroleum, the use of barges wherever feasible should be encouraged. Indeed, increased commercial use of the Upper Mississippi River and its tributaries is likely. This will be further influenced by increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments to other parts of the United States are expected to increase. ENergy demands in the Upper Midwest are also expected to rise. In addition, companies whose freight is now only infrequently involved in barging may shift from other forms of transportation to the less energy-intensive waterways. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases, economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the energy costs rise sufficiently, more capital will be needed because of the slower-moving barge transportation and larger inventories and storage space. If this occurs, other kinds of cargoes presently shipped by rail or truck or pipeline may be diverted to barge.

In addition to energy conservation, the importance of the Upper Mississippi River as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-bulk commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received and shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars, or some 3272 trains of 100 cars each, or approximately nine trains each day of the year.

<u>Barge Transportation and Air Pollution.</u> Barge transportation also results in less air pollution per ton-mile than either rail or truck modes. Diesel engines are the most common power plants used by both tugboats and railroads.

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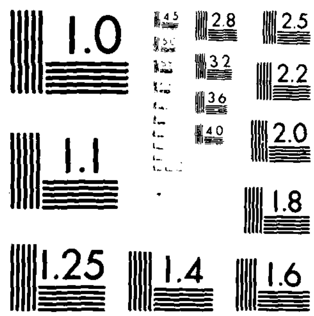

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

A large percentage of long-haul trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine because of its higher compression ratio. Thus, less energy is used to move one ton of freight over onemile by diesel than by gasoline engines. Among users of diesel engines, barging is more efficient than either rail or truck, as we have seen. Consequently, a smaller amount of fuel is required to move freight. With less fuel used, air pollution is reduced.

The concentration of air pollutants emitted from combustion of diesel fuel versus gasoline varies substantially. The following table illustrates these different concentrations (U.S.P.H.S., 1968):

	Emission Factor	
Type of Emission	Pounds/1000 gallons diesel fuel	Pounds/1000 gallons gasoline
Aldehydes (R-CHO)	10	4
Carbon monoxide (CO)	60	2300
Hydrocarbons (C_xH_y)	136	200
Oxides of Nitrogen (NO_2)	222	113
Oxides of Sulfur (SO_2)	40	9
Organic Acids (acetic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck, 4.8 times as much air pollution per ton-mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficiency of barging compared with other modes of freight transportation will result in reduced air emissions per ton-mile.

Barge Transportation and Cost Savings. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates

of these savings have been made. One of these estimates the savings over the other various least-cost alternatives of between 4.0 and 5.4 mills per ton-mile (UMRCBS, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, or move through the St. Paul District pools on river barges.

Recreational Activities

Table 46 identifies the variety of recreational activities--from boating and sport fishing to sightseeing and camping--that may be helped or hindered by Corps' operations. Ideally, it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 46 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortunately, both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities, and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities--sport fishing.

Benefits and Costs of Recreational Activities. Theoretical fram works exist to perform a benefit-cost analysis of a recreation or tourism activity. One example is a study prepared for the U.S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately, even this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

Applying even this theoretical framework to the nine-foot channel project presents both conceptual and data collection problems. For example, continuing

to operate and maintain the nine-foot channel may hurt sport fishing because of the reduction in fish habitat. This means that the *total* value of sport fishing in the river should not be considered in the analysis. Rather, only the *incremental* increase or decrease in sport fishing attributable to present Corps' operations (not caused by the initial lock and dam construction) should be weighed against those operations; no estimates are presently available to assess the effect of current Corps' operations on fish and wildlife. Also, reduced fishing and waterfowl habitat may become an increased terrestrial habitat. What the fisherman loses the hunter, trapper, or birdwatcher may gain.

This raises a second difficulty: How does one measure the total value of sport fishing on the river in order to start to measure the incremental portion attributable to Corps' operations? For sport fishing, various measures have been identified, each having its own drawbacks (Clawson and Knetsch, 1966): gross expenditures by the fishermen, market value of fish caught, cost of providing the fishing opportunity, the market value as determined by comparable privately owned recreation areas, and the direct inverview method--asking fishermen what hypotetical price they would be willing to pay if they were to be charged a fee to fish.

If some average price per fisherman or trip were available, it still would be possible to assess the total value of sport fishing in the study area *only* if estimates of the number of sport fishermen or number of sport fishing trips were avilable. In the St. Paul District these estimates are available through sport fishery surveys for only three pools: Pool 4, Pool 5, and Pool 7. The most recent data available for these pools are for the 1967-68 year (Wright, 1970); comparable data for 1972-73 have been collected, but are not expected to be published in report form until about December 1973.

Valuing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute,

1968; Pennington, *et al.*, 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks, virtually all river users are not away from home overnight and are omitted from such studies.

Information is then generally restricted to that available in the UMRCC sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

Pool Number	Total Number of Fishing Trips	Value at $5.00 per Trip*	Value at $1.50 per Trip**
4	169,361	$846,805	$254,042
5	51,786	258,930	77,699
7	63,238	318,190	94,857

*Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was $4.98 per day.
**Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit values of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.

Thus, the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benefit or cost) of Corps' operations. With the limited funds available for the present research and the limited existing data, detailed analysis is beyond the scope of the present study.

Similar problems are present in evaluating the other recreational activities in the study area.

Cultural Sites

No attempt has been made in the present study to place dollar values on archaeological, historical, or cultural sites damaged or enhanced by Corps' operations. Rather, such sites have merely been identified, where existing data permit.

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7. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH HAVE BEEN INVOLVED IN THE PROJECT SINCE IT WAS IMPLEMENTED

The construction of navigation facilities and continuing channel maintenance in Pool 1 required the irretrievable commitment of human and natural resources. Fossil fuel, labor, concrete, steel, lumber, and equipment resources were committed to the construction of Lock and Dam 1 and its appurtenant structures. There is a continuing commitment of labor, electric power and equipment resources to the annual operation and maintenance of these structures.

The annual maintenance dredging of the nine-foot channel in Pool 1 also consumes fossil fuel and labor as well as the commitment of wear and tear on vessels and equipment.

Some natural resources were and continue to be irreversibly committed to the nine-foot channel project as well. The greatest commitment is that part of the gorge which is now filled with water and sediment. More natural resources are committed as spoil is deposited along the channel. Only a return to the open, flowing river may allow erosion to broaden the gorge somewhat.

The sites on which Locks and Dam 1 were constructed removed natural river bottom and riverbank habitat. Further, riverbank as well as blufftop habitat was converted to barge terminals and storage facilities which are dependent upon the nine-foot channel.

The free-flowing river and numerous islands flooded when the dam was constructed for the six-foot channel, might return if the dam were opened (breached). However, channelization of the Mississippi may have reduced the assemblage of species characteristic of large free-flowing rivers to make their comeback unlikely.

Spoiling of dredged material is decreasing river bottom habitat and altering terrestrial habitat as well. Habitat reduction has decreased populations of some game fish, ducks and mannals in Pool 2 and perhaps in Pool 1 also. Spoiling in Pool 1 is also decreasing the size of the pool in the gorge, thus reducing the area available for riverborne recreation.

8. RECOMMENDATIONS

Certain studies should be conducted to determine specific adverse effects and alternative methods of operation and maintenance of the nine-foot channel.

FOR LONG-TERM BENEFITS TO NATURAL AND CULTURAL SYSTEMS

1. Investigate thoroughly the physical, chemical and biological (bacteriological) properties of spoil from each currently active dredging site in the pool in order to assess its value for reuse and more precisely analyze its limitations.
2. Pursue study of market potential and reuse of spoil as suggested by BSFW study (1973), using detailed analyses above. This is the only long-range solution to the detrimental impacts of spoiling. It may also reduce the need for dredging.
3. Investigate in detail damage presently occurring to natural systems in the pool as a result of spoil deposition-erosion.
4. Study effects of turbidity on aquatic organisms and waterfowl, especially in the lower reach with fine sediments.
5. Determine the best method of barging spoil to central terminal and rapid method of unloading to eliminate impact on sensitive natural habitats of value. If the effort to find commercial and private uses for the dredged sediment should fail, alternative spoil sites should be located in Pool 2 or St. Anthony Falls Upper Pool. However, it should be recognized that these are only short-term solutions to a constant long-term problem.
6. Study the sources of sediment to Pool 2 in order to locate and eliminate (or at least reduce) primary sources.
7. Study to determine better methods and/or equipment to dispose of spoil, such as at a central redistribution terminal fo sale or reuse out of the floodplain.

8. More detailed surveys should be made of the populations of fish and benthic organisms in Pool 1. An assessment should be included of the degree of sensitivity of natural systems in Pool 1 to dredging and spoiling operations. Corollary studies should be made on the enhancement of existing spoil sites for aquatic organisms and waterfowl.

9. Improve design of the Dredge Thompson cutterhead to reduce turbidity during dredging operations.

10. Experiments should be conducted to determine the best method of reducing erosion of spoil sites, including revegetation and riprapping or diking. Such studies should consider enhancement of the spoil sites to accomodate the probable future increase in recreation in the gorge caused by the development of the high-density Cedar-Riverside community. The Corps of Engineers probably could thereby make a considerable contribution toward realizing the recreation potential in this pool. Revegetation in the manner shown in Figure 63 would help retard wind and water erosion.

11. Improve arrangement of varigation charts. Rearrange them to begin with the head of navigation so they can be read in even sequence from one river mile to the next in either downstream or upstream direction.

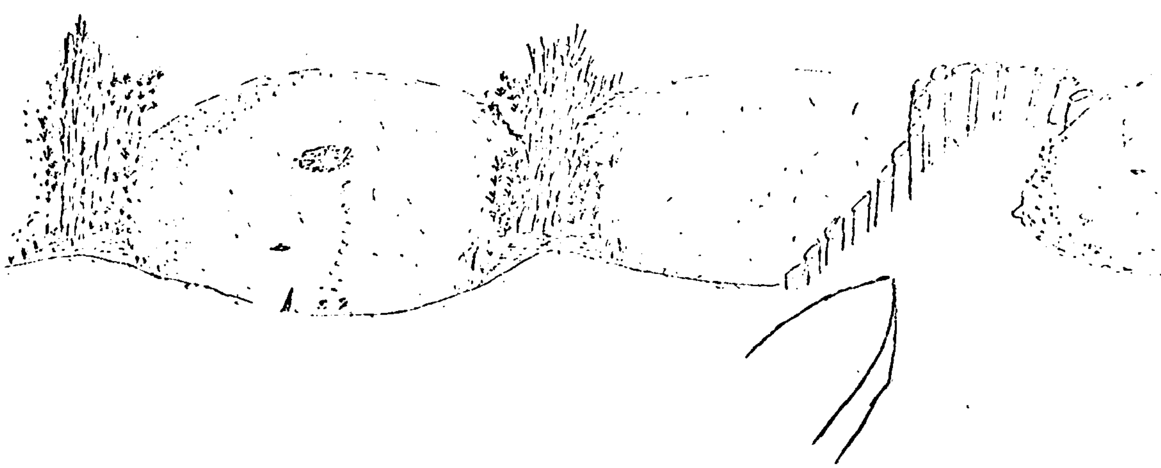

Figure 63. Recommended Alternative Method of Revegetating Spoil Sites. The screens of natural vegetation are prependicular to the current (Colingsworth and Gudmundson)

12. On the lock guidewall, orient signs perpendicular to the course of navigation so that directions for small boaters can be read as the boat approaches the guidewall within the navigation channel.
13. Investigate ways to operate with a narrower channel such as legislation requiring river pilots to be properly trained and duly licensed, and embedding a sonar guidance device on difficult curves.
14. Formulate plan and implement to eventually remove all facilities and structures from floodplain, except those that can withstand flooding with no protection, so that natural system may return to enhance the riverscape and all urban structures are out of danger.
15. Study of fish, clam, etc., migration and devise ways to enhance it at Lock and Dam 1.
16. Conduct a survey of future land use needs and potential of this reach of Mississippi Valley similar to that being done for the St. Croix Valley.
17. Develop and implement plan to use natural vegetation to space terminals between natural areas and reduce to a minimum the terminal facilities. Encourage structures and stockpiles be located outside the floodplain or at least at highest levels of the floodplain.
18. Study measures to revegetate levees, which are biological deserts which block access to the river and are aesthetically displeasing.
19. Paint the barges in more attractive colors. This would make them more easily seen at twilight and improve aesthetics compared with the present rusty brown.
20. Repair auxilliary lock for use by pleasure boats, especially because this traffic is likely to increase as water quality improves in Pool 1 and as the St. Anthony Falls area is redeveloped (see Minneapolis Plan. and Developmt., 1972).

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9. APPENDIX A: NATURAL SYSTEMS

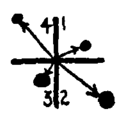
I. METHODS OF DATA COLLECTION

Methods for Collecting Samples

Biological Measurements

Benthic organisms were sampled using a Petersen (rarely, Ekman) dredge. Vegetation cover, in acres, was determined by planimetry from aerial photos, with subsidiary ground investigations to identify species, and to determine abundance, age and growth rate. Both quadrat (percent cover of herbs, etc. in one square meter) and point quarter methods (for trees) were employed.

QUADRAT
percent cover
of each species
reported



POINT QUARTER
percent frequency
of tree species
reported

Measurement of Physico-chemical Parameters

Temperature was measured by a thermister and a Precision Scientific Instruments meter, standardized to a precision mercury thermometer (APHA et al., 1971).

Dissolved oxygen was measured using a galvanic cell-type probe and a Precision Scientific Instruments meter, standardized to the Winkler titration, azide modification (APHA et al., 1971).

Turbidity was measured by nephelometry using a Horizon Ecology, Inc. nephelometer Model 104 (APHA et al., 1971).

Water depth was measured with sonar using a Heathkit Electronics Company Model M1-101-2.

Slope angle was measured using an instrument made at North Star Research.

Light penetration (transparency) was determined by suspending a 20 cm. Secchi disc with a marked cord (Golterman, 1970) in the water.

II. MAP OF POOL 1 AND TRANSECT LOCATION

The map of Pool 1 (See Figure 1) shows the location of sampling stations along "standard" and "special" transects. Standard transects are surveyed lines which cross the river at a right angle in each pool and are chosen to sample its broad environmental diversity. They extend from bluff to bluff and include bluff slope, river banks, marsh, open river and river bottom. However, on long transects most of the sampling effort will be concentrated on the smaller area between the railroad tracks on each side of the river. Standard transect AA is located about 1/4 mile downstream from the upper dam, the area most river-like and perhaps least modified by impoundment; transect BB is located near mid-pool (See Figure 2) close to the primary control point, often the marsh zone; and transect CC is located 1/4 mile upstream from the lower dam in the deeper, lake-like region.

Similarly, special transects (XX,YY) were used to study features of particular interest, such as the mouths of major tributaries, previously studied sites, and spoil sites. *The azimuth* (compass direction, using N as 0 and E as 90 degrees) and other pertinent data is given in Table 1.

Sampling stations were located along these transects, and clustered mainly in areas of transition between types of habitat such as shallow stump field to deeper river channel and forest to bare sandy soil.

In order to gather more detailed information within some habitats, "secondary" transects were located perpendicular to the standard or special transects. Sampling stations were located ramdomly along these secondary transects.

Sampling Frequency

Field data to corroborate and expand the aerial survey of the terrestrial vegetation was completed in October.

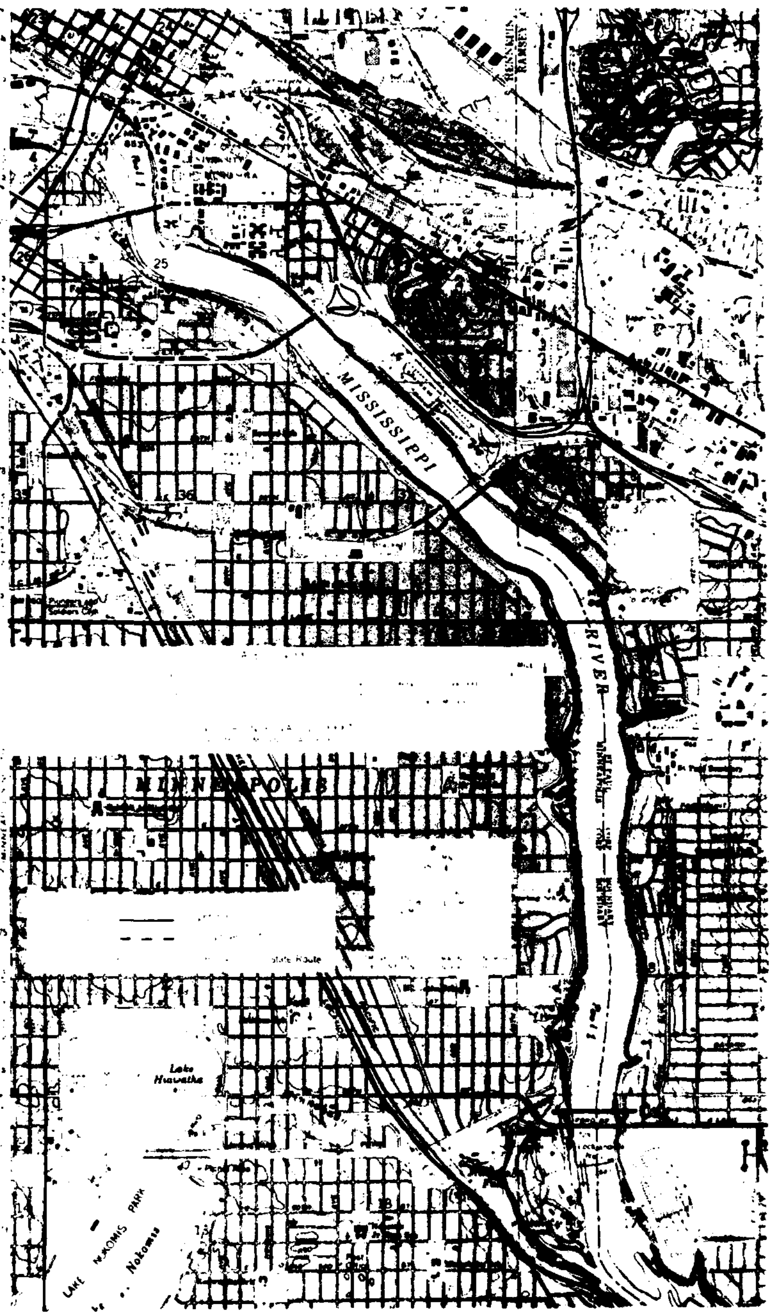


Figure 1. Map of Pool 1, Mississippi River Mile 847.6 to 853.3 (USGS, 1967).

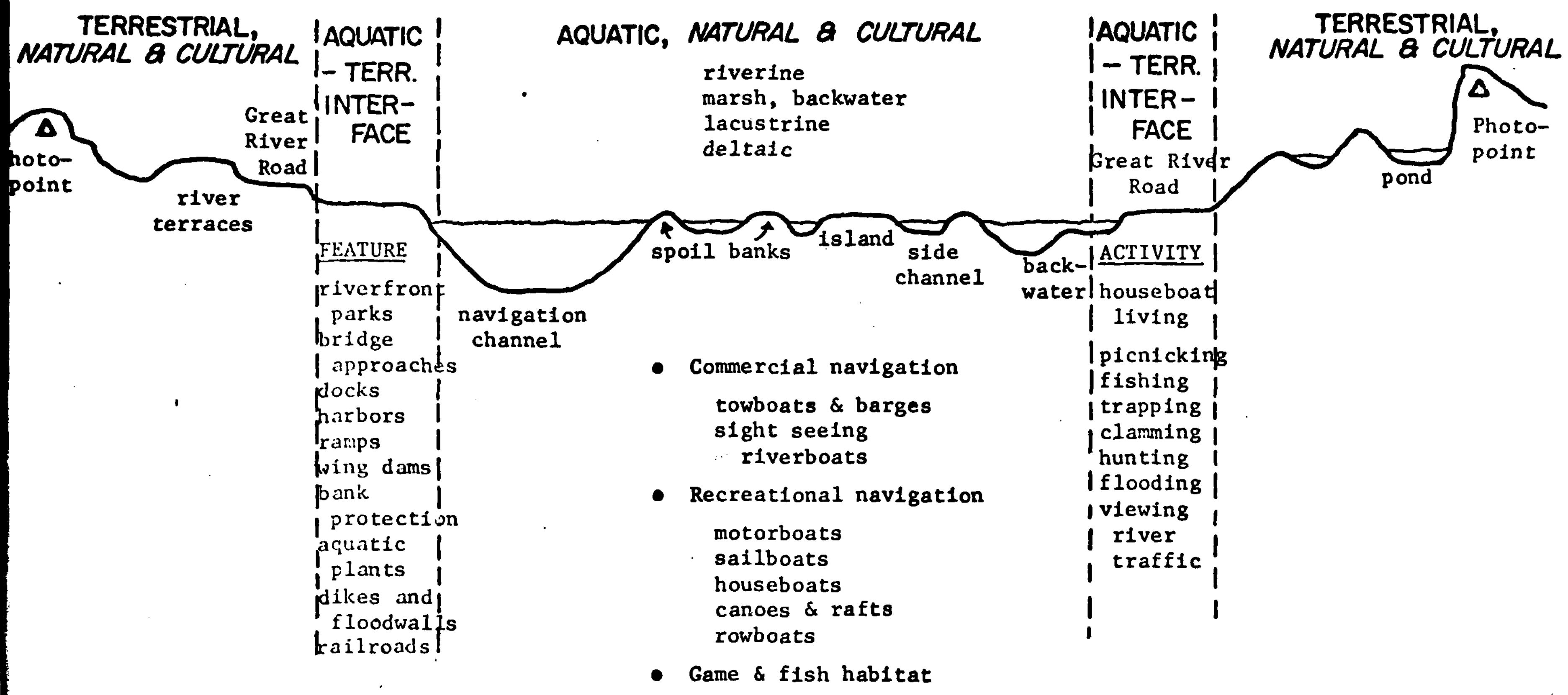


Figure 2. Profile of a Typical Transect of the Marsh Portion of a Typical Pool.

Note that the figure also lists the various environmental features that may be found at various places along the transect.

Source: ESD - North Star --Gudmundson, 1972

Table 1. Description of Transects.

Pool; Pool Length	Transect Designation	River Mile Above Cairo, IL	Azimuth	Transect Length in Miles	Azimuth target, Location
USAF 3.6	Standard Transect UAA	858.9	86°	.15	SW corner of Minneapolis Water Works Bldg.
	Standard Transect UBB	855.7	278°	.13	Line up downstream legs of tower for high voltage line.
	Standard Transect UCC	854.4	52°	.31	Line up with D/S face of old limestone apt. bldg.
LSAF 0.6	Standard Transect LBB	853.4	175°	.15	Mooring cell ladder on R/B nearest lower L/D.
Pool 1 5.7	Standard Transect 1AA	853.1	28°	.15	Center of high-rise apt. bldg. on R/B.
	Special Transect 1XX	851.1	39°	.21	Gov't. daymark Mile 851.1; on spoil on L/B
	Standard Transect 1BB	850.6	46°	.15	Vertical seam on Platteville L.S. on left bluff
	Special Transect 1YY	849.4	99°		Oval pipe opposite; on R/B spoil downstream from Lake St. Bridge. Mid-stream azimuth 35° to WMIN radio tower, L/B.
	Standard Transect 1CC	848.0	86°	.20	Line up downstream face of high-rise apt. tower on L/B (720 River Terrace).
Pool 2 32.4	Standard Transect 2AA	847.4	263°	.15	Chimney on north wing (with white,round porch of MN Soldiers' Home Bldg.
	Standard Transect 2BB	831.7	264°	1.10	Gov't. (USCG) daymark Mile 831.7 R/B
	Special Transect 2YY	821.3,R	54°	1.10	Tall smokestack right of L/B water tower; transect runs from mid-channel to R/B, sampled by Hokanson in 1964.
	Standard Transect 2CC	815.5	52°	1.00	Tip of peninsula which extends 0.35 mi. upstream 4D #2.
	Special Study Area	833.2,R	54°	—	Mi. 833.1 Gov't daymark, 22?-yr-old R/B spoil site
	Special Study Area	832.0,L	256°	—	Tower for high voltage line on R/B, 8?-yr-old spoil site 4B.
	Special Study Area	827.7,R	85°	—	Gov't daymark Mi. 827.7, 2?-yr-old spoil site
Minn. R. 26.4	Standard Transect MAA	M24.8	347°	1.00	Second bend above Shakopee (US 169) Bridge
	Standard Transect MBB	M13.0	335°	1.05	Gov't. daymark, Mile 12.5
	Standard Transect MCC	M3.0	128°	.90	Gov't. daymark, Mile 2.9
St. Croix River 25.0	Standard Transect SAA	SC24.8	305°	.50	White bldg., right bank.
	Special Transect SXX	SC16.6	85°	.50	Upstream edge of bldg. at Lakefront Park.
	Standard Transect SBB	SC12.3	111°	1.05	Road coming down bluff to beach.
	Special Transect SYY	SC 6.4	291°	.38	Shallow dip in tree line on right bank
	Standard Transect SCC	SC 0.7	85°	.90	Fence marking upstream boundary of public beach on left bank.

Benthic samples were collected in April, and May and again in August and September. Water quality data was collected in September and early November.

III. SUMMARY OF DATA COLLECTION POINTS AND TIMES

Benthic (bottom) grab samples were taken on all standard and special transects during the months of April and May and in August. Sediments were washed out using a 707 standard mesh screen, and organisms preserved. Identifications were made by Mr. Daniel Maschwitz, graduate student in the Department of Entomology, Fisheries and Wildlife, University of Minnesota.

The width of vegetation zones intersected by the transects was measured and one meter square quadrats and/or point quarter stations were used to determine the abundance of plant species. Plant species identifications were made in the field, and checked by Dr. Gerald Ownby, Curator of the Herbarium, Department of Botany, University of Minnesota.

Field data and pertinent data from the literature are presented on data sheets in Appendix A,IV.

IV. DATA SHEETS

Table 1. Abundance of Plants Found in the River Valleys.

Table 2. Vegetation of Floodplain and Bluff Habitats (Cooper, 1947).

Table 3. Vegetation of Spring Lake Area (Leisman, 1959).

Table 4. Birds of the Minneapolis-St. Paul Area (Dodge, *et al.*, 1971).

Table 5. Water Quality of the Mississippi River Measured at Intake of the Minneapolis Water Works in Fridley.

Table 6. Turbidity, Temperature and Dissolved Oxygen in the SAF, Pool 1 and 2 in the Mississippi River, and in the lower Minnesota River, November, 1973.

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area

(P - present; M - moderate; D - dominant)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees and Shrubs</u>																	
ACERACEAE																	
Acer negundo Box elder	P	P	P	P	P		P		P	P	P	P					
Acer nigrum Black maple																	
Acer rubrum Red maple					P												
Acer saccharinum Silver or soft maple							P					P		P		P	
Acer saccharum Sugar or hard maple						P	P							P			
Acer spicatum Mountain maple																	
Acer sp. Maple													P				
ANACARDIACEAE																	
Rhus glabra Smooth sumac				P	P												
Rhus radicans Poison ivy																	
Rhus typhina Staghorn sumac						P									P		P

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (cont'd.)</u>																	
BETULACEAE																	
Alnus incana Speckled alder																	
Betula papyrifera Paper birch							P			P				P	P	P	P
Carpinus caroliniana Blue beech or hornbeam																	
Ostrya virginiana Ironwood or hop hornbeam				P						P						P	
CAPRIFOLIACEAE																	
Diervilla lonicera Bush honeysuckle																	
Lonicera prolifera Grape honeysuckle																	
Lonicera tatarica Tartarian honeysuckle										P							
Sambucus canadensis Common elder														P			
Sambucus pubens Red-berried elder				P		P											
Symphoricarpos occidentalis Wolfberry																	
Symphoricarpos orbiculatus Coralberry																	
Viburnum cassinoides Wild raisin																	
CELASTRACEAE																	
Celastrus scandens Climbing bittersweet																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
CORNACEAE																	
Cornus alternifolia Alternate-leaved dogwood																	
Cornus racemosa Panicled dogwood																	
Cornus stolonifera Red-osier dogwood																	
CUPRESSACEAE																	
Juniperus virginiana Red cedar										P						P	P
Thuja occidentalis White cedar																	
FABACEAE (LEGUMINOSAE)																	
Amorpha fruiticosa False indigo							P										
Robinia pseudo-acacia Black locust							P			P							
FAGACEAE																	
Quercus alba White oak																	
Quercus macrocarpa Bur oak or mossycup oak															P		
Quercus borealis Northern red oak							P			P						P	P
Quercus velutina Black oak															P		
Quercus sp. Oak																P	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees & Shrubs (Cont'd.)																	
JUGLANDACEAE																	
Carya cordiformis Bitternut hickory			P				P										
LEGUMINOSAE: see FABACEAE																	
MORACEAE																	
Morus rubra Red mulberry						P											
OLEACEAE																	
Fraxinus nigra Black ash												P	P				
Fraxinus pennsylvanica var. *subintegerrima* Green ash			P			P	P										
Fraxinus sp. Ash	P			P	P					P				P	P	P	P
PINACEAE																	
Larix laricina Tamarack																	
Picea canadensis White spruce																	
Pinus resinosa Red pine															P		
Pinus strobus White pine																P	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
ROSACEAE																	
Amelanchier huronensis Service-berry, Shadbush)																	
Amelanchier spp. Juneberry																	
Crataegus spp. Thorn-apple																	
Physocarpus opulifolius Ninebark																	
Prunus americana Wild plum																	
Prunus pensylvanica Pincherry																	
Prunus serotina Black cherry										P							
Prunus virginiana Choke-cherry							P										
SALICACEAE																	
Populus deltoides Cottonwood	M	D	P	P	P		P	P		P	P		P		P	P	P
Populus grandidentata Bigtooth aspen							P			P							
Populus balsamifera Balsam poplar																	P
Populus tremuloides Quaking aspen	P																P
Populus sp. Aspen	P																

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
SALICACEAE (Cont'd.)																	
Salix alba																	
White willow						P											
Salix amygdaloides																	
Peach-leaved willow		P				P								P			
Salix humilis																	
Small pussy-willow																	
Salix interior																	
Sandbar willow					P	P	P	P		P	P	P	P		P	M	
Salix nigra																	
Black willow																	
Salix spp.																	
Willows																	
TAXACEAE																	
Taxus canadensis																	
Yew														P			
TILIACEAE																	
Tilia americana																	
American basswood						P	P							P			P
ULMACEAE																	
Celtis occidentalis																	
Hackberry			D														
Ulmus americana																	
American elm	P		P	P	P	P	P		P			P		P			
Ulmus pumila																	
Dwarf elm	P		P	P		P											

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
ULMACEAE																	
Ulmus rubra Slippery elm			P	D		P											
Ulmus sp. Elm	P				P					P					P	P	P
<u>Vines (lianas)</u>																	
VITACEAE																	
Parthenocissus quinquefolia Virginia creeper	P	P		P	P	P	P						P				
Vitis riparia Riverbank grape	P	D			P		P		P			P			P	P	
<u>Herbs</u>																	
AIZOACEAE																	
Mollugo verticillata Carpetweed																	
ALISMACEAE																	
Sagittaria sp. Arrowhead																	
AMARANTHACEAE																	
Amaranthus tamarincus (or tuberculata) Amaranth	P				P			P				P					
APOCYNACEAE																	
Apocynum androsaemifolium Dogbane							D										

Table 1 . Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF											Minn.			St. Croix			
Pool:	Upper			Lower	1			2			River			River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
ARACEAE																	
Arisaema triphyllum Jack-in-the-pulpit																	
Spathyema foetida Skunk cabbage																	
ARALIACEAE																	
Aralia nudicaulis Wild sarsaparilla																	
Panax quinquefolius Ginseng																	
Panax trifolius Dwarf ginseng																	
Hedera helix English ivy				P													
ARISTOLOCHIACEAE																	
Asarum canadense Canadian wild ginger														P			
ASCLEPIADACEAE																	
Asclepias exaltata Tall milkweed																	
Asclepias ovalifolia Oval-leafed milkweed																	
Asclepias syriaca Common milkweed					P	P	P										
Asclepias tuberosa Butterflyweed																	
Asclepias verticillata Whorl-leaved milkweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix RIver			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
BALSAMINACEAE																	
Impatiens sp. Jewelweed										P				P	P		P
BORAGINACEAE																	
Hackelia virginiana Beggar's lice																	
Lappula redowskii Stickseed																	
Lithospermum canescens Puccoon, Indian-paint																	
Lithospermum carolinense Puccoon																	
Lithospermum incisum Puccoon																	
Onosmodium molle Marble-seed, False gromwell																	
Myosotis sp. Forget-me-not														P			
CAMPANULACEAE																	
Campanula rotundifolia Harebell																	
Lobelia sp. Lobelia														P			
CAPPARIDACEAE																	
Polanisia trachysperma Rough-seeded clamyweed								P									

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Pool: Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	Pool 1 AA	Pool 1 BB	Pool 1 CC	Pool 2 AA	Pool 2 BB	Pool 2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
<u>Herbs (Continued)</u>																	
CAPRIFOLIACEAE																	
Triosteum perfoliatum Horse-gentian																	
CARYOPHYLLACEAE																	
Cerastium arvense Field chickweed																	
Cerastium nutans Nodding chickweed																	
Cerastium vulgatum Common mouse-ear chickweed														P			
Saponaria officinalis Soapwort, Bouncing bet																	
Stellaria aquatica Water chickweed																	
CERATOPHYLLACEAE																	
Ceratophyllum demersum Coontail																	
CHENOPODIACEAE																	
Chenopodium album White pigweed	P										P						
Chenopodium gigantospermum Pigweed			P														
Corispermum hyssopifolium Hyssop-leaved pigweed		P															
Cyclolama atriplicifolium Winged pigweed						P											

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CISTACEAE																	
Helianthemum bicknellii Frostweed																	
COMMELINACEAE																	
Tradescantia bracteata Bracted spiderwort																	
Tradescantia occidentalis Western Spiderwort																	
COMPOSITAE																	
Achillea millefolium Yarrow																	
Ambrosia artemisiifolia Common ragweed	P			P										P			
Ambrosia sp. Ragweed		P						P									
Antennaria plantaginifolia Pussytoes																	
Anthemis cotula Mayweed																	
Arctium minus Burdock																	
Artemisia biennis Biennial wormwood	P										P		P				
Aster novae-angilae New England aster																	P
Aster spp. Aster									D	P		P	P	P			P

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
COMPOSITAE (Continued)																	
Bidens beckii Water marigold																	
Bidens connata Beggar's ticks																	
Bidens sp. Bur marigold	P			P							P		P				
Carduus nutans Musk thistle																	
Cirsium arvense Canada thistle		P			P							P					
Crepis tectorum Hawk's beard																	
Erigeron annuus Daisy fleabane		P		P			P										
Erigeron canadensis Horseweed		P															
Erigeron philadelphicus Fleabane											P						
Erigon pulchellus Robin's plantain																	
Erigeron strigosus White-top																	
Eupatorium maculatum Joe-Pye weed																	
Eupatorium perfoliatum Thoroughwort																	
Eupatorium rugosum White snakeroot	D	P	P	P	P	P	P										

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
COMPOSITAE (Continued)																	
Grindelia squarrosa Curlycup-gumweed																	
Helianthus occidentalis Western sunflower																	
Helianthus petiolarus Petioled sunflower					P												
Heliopsis helianthoides Ox-eye		P															
Krigia biflora Dwarf dandelion																	
Lactuca sp, Lettuce		P			P					P	P	P					
Prenanthes alba Rattlesnake root																	
Ratibida pinnata Coneflower																	
Rudbeckia hirta Black-eyed Susan																	
Senecio pauperculus Ragwort																	
Senecio plattensis Ragwort																	
Silphium perfoliatum Cup-plant, Rosinweed																	
Solidago altissima Tall goldenrod					P												
Solidago flexicaulis Zig-zag goldenrod																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	1 AA	1 BB	1 CC	2 AA	2 BB	2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
<u>Herbs (Continued)</u>																	
COMPOSITAE (Continued)																	
Solidago gigantea Giant goldenrod		P															
Solidago graminifolia Grass-leaved goldenrod																	
Solidago nemoralis Gray goldenrod																	
Solidago so. Goldenrod	P			P	P			P	P	P			P	P	P	P	P
Taraxacum officinale Dandelion		P		P		P					P		P			P	P
Vernenia fasciculata Western ironweed								P									
Xanthium italicum Common cocklebur	P	P		P		P	P	P			P						
CRUCIFERAE																	
Berteroa incana Hoary alyssum																	
Brassica nigra Black mustard																	
Cardamine pensylvanica Bitter cress																	
Hesperis matronalis Dames violet																	
Lepilium virginicum Poor-man's pepper	P																
Nasturtium officinale Watercress														P			

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CRUCIFERAE (Continued)																	
Rorippa islandica Icelandic yellow cress																	
Rorippa obtusa Obtuse yellow cress																	
Unidentified sp.	P																
CUCURBITACEAE																	
Sicyos angulatus Bur-cucumber					P												
CYPERACEAE																	
Carex aenea Sedge																	
Carex annectens Sedge																	
Carex cephalophora Oval-headed sedge																	
Carex communis Sedge																	
Carex stenophylla Involute-leaved sedge																	
Carex laxiflora Sedge																	
Carex lurida Sedge																	
Carex meadii Sedge																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	Pool 1 AA	Pool 1 BB	Pool 1 CC	Pool 2 AA	Pool 2 BB	Pool 2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
Herbs (Continued)																	
CYPERACEAE																	
Carex normalis Sedge																	
Carex sartwellii Sartwell's sedge																	
Carex stipata Awl-fruited sedge																	
Carex umbellata Sedge																	
Carex vulpinoidea Fox sedge																	
Cyperus filiculmis Galingale																	
Cyperus inflexus (or aristotus) Awned cyperus								P			P						
Cyperus orbiculari Galingale								P									
Cyperus schweinitzii Galingale																	
Cyperus sp. Galingale											P						
Eleocharis palustris Spike-rush																	
Hemicarpha micrantha Least hemicarpha								P									
Scirpus americanus Sword grass																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CYPERACEAE																	
Scirpus atrovirens Georgian bulrush																	
Scirpus cyperinus Woolgrass																	
Scirpus rubrotinctus Bulrush																	
Scirpus validus Giant bulrush																	
Unidentified sp.													P	P		P	
DIOSCOREACEAE																	
Dioscorea villosa Wild yam																	
EQUISETACEAE																	
Equisetum arvense Field horsetail							P			D	P	P	P	P			
Equisetum hyemale Scouring rush																	
Equisetum pratense Meadow horsetail																	
EUPHORBIACEAE																	
Euphorbia corollata Flowering spurge																	
Euphorbia cyparissias Cypress spurge																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
EUPHORBIACEAE (Continued)																	
Euphorbia esula																	
Leafy spurge		P		P							P						
Euphorbia sp.																	
Spurge			P					P									
Euphorbia glyptosperma																	
Engraved-seed spurge																	
Euphorbia nutans																	
Eyebane																	
FABACEAE (LEGUMINOSAE)																	
Amorpha canescens																	
Prairie lead-plant																	
Astragalus crassicarpus																	
Ground plum																	
Medicago lupulina																	
Black medick			P		P												
Melilotus alba																	
White sweet clover	P	M			P	D	P					P				P	
Petalostemum candidum																	
White prairie clover																	
Vicia cracca																	
Tufted vetch																	
Vicia villosa																	
Hairy vetch																	
GERANIACEAE																	
Geranium spp.																	
Wild geranium				P													

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
GUTTIFERAE																	
Hypericum sp. St. John's-wort																	P
GRAMINEAE																	
Agrostis palustris Creeping bentgrass										P							
Bouteloua curtipendula Side-oats grama																	
Calamagrostis canadensis Reed bentgrass	P																
Echinochloa sp.	D				P	P		p			p						
Elymus canadensis Canadian wild rye						P				P							
Elymus virginicus Virginian wild rye	P																
Eragrostis hirsuta Hairy love-grass	P										P		D				
Eragrostis hypnoides Creeping love-grass	D																
Eragrostis pectinacea Pursh's love-grass	D							P			M	P					
Glyceria grandis Reed meadow-grass																	
Glyceria striata Fowl meadow-grass																	
Panicum capillare Witch grass	M							P			P	P			P		
Panicum depauperatum Panic grass																	

Table. 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species: Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
GRAMINEAE (Continued)																	
Panicum dichotomiflorum Spreading witch grass	P																
Panicum virgatum Switch grass											P						
Phalaris arundinacea Canary grass																	
Poa palustris Fowl meadow-grass		P															
Poa pratensis Blue grass																	
Setaria viridis Green foxtail		P				P		P				P				D	
Setaria sp. Bristly foxtail													P				
Spartina pectinata Prairie cord grass								P									
Unidentified sp.	D				P		P										
HYDROCHARITACEAE																	
Vallisneria spiralis Wild celery																	
HYDROPHYLLACEAE																	
Ellisia nyctelea (No common name)																	
Hydrophyllum appendiculatum Virginia waterleaf																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
HYPERICACEAE																	
Hypericum perforatum St. John's-wort																	
Hypericum punctatum Spotted St. John's-wort																	
IRIDACEAE																	
Sisyrinchium campestre Blue-eyed grass																	
JUNCACEAE																	
Juncus balticus Spikerush																	
Juncus compressus Spikerush																	
Juncus effusus Spikerush																	
Juncus longistylis Spikerush																	
Juncus secundus Spikerush																	
LABIATAE																	
Galeopsus tetrahit Hemp-nettle																	
Glecoma hederacea Creeping Charlie																	
Hedeoma hispida Mock pennyroyal																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
LABIATAE (Continued)																	
Leonurus cardiaca																	
Motherwort						P					P						
Lycopus officinalis																	
Water horehound																	
Lycopus virginicus																	
Bugleweed																	
Monarda fistulosa																	
Wild bergamot, horsemint																	
Mentha arvensis																	
American wild mint			P					P									
Nepeta cataria																	
Catnip					P												
Physostegia virginiana																	
Obedient plant																	
Prunella vulgaris																	
Mad-dog skullcap																	
Scutellaria lateriflora																	
Leonard's skullcap																	
Stachys palustris																	
Hedge-nettle			P														
Teucrium canadense																	
American germander																	
Unidentified sp.			P					P	P							P	
LEMNACEAE																	
Lemna spp.																	
Duckweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
LILIACEAE																	
Allium cernuum Wild onion																	
Lilium superbum Turk's-cap lily																	
Maianthemum canadense Wild lily-of-the-valley																	
Smilacina spp. False Solomon's seal																P	
Smilax sp. Greenbrier																P	
Trillium spp. Trillium																	
LOBELIACEAE																	
Lobelia spicata Highbelia, pale-spike lobelia																	
MENISPERMACEAE																	
Menispermum canadense Yellow parilla						P											
NAJADACEAE																	
Najas sp. Naiad																	
Zannichellia palustris Horned pondweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
NYCTAGINACEAE																	
Mirabilis hirsuta																	
Hairy umbrellawort		P															
ONAGRACEAE																	
Circaea quadrisulcata																	
Tall enchanter's nightshade																	
Epilobium ciliatum																	
Willow herb																	
Epilobium paniculatum																	
Willow herb																	
Oenothera biennis																	
Evening primrose		P															
OPHIOGLOSSACEAE																	
Botrychium virginianum																	
Rattlesnake fern																	
OSMUNDACEAE																	
Osmunda claytoniana																	
Cinammon fern															P		
OXALIDACEAE																	
Oxalis dillenii																	
Wood sorrel											P						
Oxalis stricta																	
Upright wood sorrel																	
Oxalis violacea																	
Violet wood sorrel																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
PAPAVERACEAE																	
Sanguinaria canadensis Bloodroot																	
PHYRMACEAE																	
Phyrma leptostachya Lopseed																	
PLANTAGINACEAE																	
Plantago major Common plantain	M									P		P	P				
Plantago rugelii Wood plantain																	
POLEMONIACEAE																	
Phlox divaricata Blue phlox																	
Phlox pilosa Phlox																	
Polemonium reptans Jacob's ladder																	
POLYGONACEAE																	
Polygonum ariculare Common knotweed																	
Polygonum coccineum Scarlet smartweed																	
Polygonum pensylvanicum Pennsylvania smartweed					P			P									
Polygonum sp. Smartweed	P										P	P	P				

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF															
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River		
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
POLYGONACEAE (Cont'd.)																	
Rumex acetosella Sheep sorrel																	
Rumex crispus Curled dock		P											P				
Rumex mexicanus Mexican dock	P																
Rumex sp. Dock		P			P						P			P		P	
POLYPODIACEAE																	
Adiantum pedatum Maidenhair fern																	
Cystoperis fragilis Fragile bladder-fern														P	P	P	
PRIMULACEAE																	
Lysimachia nummularia Moneywort																	
Lysimachia ciliata Loosestrife																	
RANUNCULACEAE																	
Anemone canadensis Canadian amenome																	
Anemone caroliniana Carolina anemone																	
Anemone cylindrica Thimbleweed																	
Anemone quinquefolia Wood anemone																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
RANUNCULACEAE																	
Anemone virginiana Thimbleweed																	
Anemone sp. Anemone														P	P	P	P
Anemonella thalictroides Rue anemone																	
Aquilegia canadensis Columbine													P	P			
Delphinium virescens Larkspur																	
Hepatica acutiloba Liverleaf, hepatica										P							
Hepatica americana Liverleaf, hepatica																	
Ranunculus acris Tall buttercup																	
Ranunculus abortivus Kidneyleaf buttercup																	
Ranunculus aquatilis White water-crowfoot																	
Ranunculus pensylvanicus Bristly crowfoot																	
Ranunculus rhomboideus Prairie buttercup																	
Ranunculus sceleratus Cursed crowfoot											P						
Ranunculus septentrionalis Swamp buttercup																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
ROSACEAE																	
Potentilla recta Upright cinquefoil																	
Potentilla simplex Old-field cinquefoil																	
Potentilla sp. Cinquefoil											P		P				
Rosa blanda Smooth wild rose										P							
Rosa suffulta Hairy prairie rose																	
Rosa sp. Rose													P		P		
Rubus occidentalis Black raspberry																	
RUBIACEAE																	
Galium boreale Northern bedstraw																	
Galium trifidum Small bedstraw																	
Houstonia longifolia Bluet																	
SANTALACEAE																	
Comandra umbellata Bastard toadflax																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	Pool: SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
RANUNCULACEAE (Cont'd.)																	
Ranunculus sp. Buttercup											P						
Thalictrum dasycarpum Purple meadow-rue																	
Thalictrum sp. Meadow-rue										P				P			
RHAMNACEAE																	
Ceanothus americanus New Jersey tea																	
ROSACEAE																	
Agrimonia pubescens Cocklebur																	
Alchemilla sp. Lady's mantle													P				
Fragaria vesca Wild strawberry																	
Geum canadense White avens																	
Geum laciniatum Avens																	
Geum triflorum Three-flowered avens																	
Potentilla argentea Silvery cinquefoil																	
Potentilla arguta Tall cinquefoil																	
Potentilla norvegica Rough cinquefoil											A						

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
SAXIFRAGACEAE																	
Heuchera americana Alumroot																	
Heuchera richardsonii Richardson's alumroot																	
Ribes sp. Currant											P					P	
SCROPHULARIACEAE																	
Besseya bullii (No common name)																	
Linaria vulgaris Butter-and-eggs					P												
Mimulus glabratus Monkey-flower																	
Mimulus ringens Square-stemmed monkey-flower											P						
Penstemon gracilis Slender-leaved beard-tongue																	
Penstemon grandiflorus Large-flowered beard-tongue																	
Scrophularia lanceolata Figwort																	
Verbascum thapsus Mullein																	
Veronica americana Speedwell																	
Veronicastrum virginicum Culver's root																	
Unidentified sp.	P																

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
SOLANACEAE																	
Physalis heterophylla Clammy ground-cherry																	
Physalis longifolia Ground-cherry																	
Solanum nigrum var. *americana* Black nightshade			P	P					P		P						
SPARGANIACEAE																	
Sparganium Bur-reed																	
TYPHACEAE																	
Typha latifolia Cattail														P			
UMBELLIFERAE																	
Angelica atropurpurea Alexander																	
Cryptotaenia canadensis Wild chervil																	
Heracleum lanatum Cow parsnip																	
Osmorhiza longistylis Sweet cicely																	
Pastinaca sativa Wild parsnip																	
Sanicula marilandica Black snakeroot																	
Zizea aurea Golden alexander																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	Pool: SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
URTICACEAE																	
Boehmeria cylindrica False nettle																	
Parietaria pensylvanica Pennsylvania pellitory	P	D															
Urtica dioica Stinging nettle											P						
Laportia canadensis Canadian wood-nettle										P							
Unidentified sp.		P							P				P	P			
VERBENACEAE																	
Verbena bracterata Large-bracted vervian	P																
Verbena hastata Blue vervain																	
Verbena simplex Vervain																	
Verbena stricta Hoary vervain																	
Verbena urticifolia White vervain																	
VIOLACEAE																	
Viola pedata Bird's-foot violet																	
VITACEAE																	
Parthenocissus inserta Thicket creeper, woodbine																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
HEPATICAE (Liverworts)														P			
MUSCI (mosses)														P	P	P	P

Table 2. Vegetation of Floodplain (old dredge spoil) and Bluff Habitats on the Minnesota River (Cooper, 1947).

Trees	
Acer negundo	Box elder
Acer saccharinum	Soft (Silver) Maple
Fraxinus nigra	Black ash
Fraxinus pennsylvanica	White ash
Fraxinus sp.	Ash
Populus deltoides	Cottonwood
Salix amygdaloides	Beech-leaved willow
Ulmus americana	American elm
Ulmus rubra	Slippery elm
Shrubs	
Cornus stolonifera	Red-osier dogwood
Cornus racemosa	Racemose dogwood
Salix longifolia	Willow
Sambucus canadensis	Common elder
Vitis riparia	River-bank grape
Herbs	
Acalypha rhombodia	Three-seeded mercury
Anemone virginiana	Tall anemone
Aster lateriflorus	Calico aster
Aster sp.	
Bidens sp.	Stick-tights
Boehmeria cylindrica	False nettle
Boltonia latisquama	Small headed boltonia
Carex gracilima	Sedges
Cuscuta sp.	Dodder
Elymus virginicus	Virginia wild rye
Eupatorium perfoliatum	Common boneset
Geum sp.	
Helenium autumnale	Sneezeweed
Heuchera richardsonii	Alum root
Laportia canadensis	Wood nettle
Lathyrus sp.	Wild pea
Leersia oryzoides	Rice cut-grass
Lycopus virginicus	Bugle weed
Menispermum canadense	Moonseed
Mentha sp.	Mint
Physostegia speciosa	False dragon-head
Plantago major	Common plantain
Oryzopsis sp.	
Stachys aspera	Rough hedge nettle
Urtica gracilis	Slender wild nettle

Table 3. Vegetation of the Spring Lake area (Data from Leisman, 1959).

HABITAT: Ravines and Bluffs	HABITAT: River Terraces and Uplands
Trees - common	**Trees**
American elm *Ulmus americana*	Northern red oak *Quercus borealis*
Slippery elm *Ulmus rubra*	Pin oak *Q. palustris*
Basswood *Tilia americana*	Bur oak *Q. macrocarpa*
Green ash *Fraxinus pennsylvanica* var. *subintegerrima*	American elm *Ulmus americana*
Box elder *Acer negundo*	Bitternut hickory *Carya cordiformis*
Cottonwood *Populus deltoides*	Butternut *Juglans cinerea*
Red cedar *Juniperus virginiana*	Hackberry *Celtis occidentalis*
- present	
Ironwood *Ostrya virginiana*	
Butternut *Juglans cinerea*	
Oaks (several) *Quercus* spp.	
Paper birch *Betula papyrifera*	
Shrubs - common	**Shrubs**
Red-berried elder *Sambucus pubens*	None
Missouri gooseberry *Ribes missouriense*	
Prickly gooseberry *Ribes cynosbati*	
Black raspberry *Rubus occidentalis*	
Prickly ash *Xanthoxylum americanum*	
Hazel *Corylus americana*	
- present	
Wolfberry *Symphoricarpos occidentalis*	
Herbs	**Herbs**
Yellow jewelweed *Impatiens pallida*	Kentucky bluegrass *Poa pratensis*
Nettle *Urtica procera*	
Sweet cicely *Osmorhiza* sp.	

Table 4.

The Birds of the Minneapolis-St. Paul Region

This combined field list and migration chart of birds for the Twin Cities and the surrounding area (see unlined area on map) is designed to fit inside A FIELD GUIDE TO THE BIRDS by R. T. Peterson and to be taken into the field as an aid to those who enjoy birding in this region. The list comprises all of the species authoritatively recorded for this area, plus a few based on sight records only. It is hoped that this list may encourage the accumulation of further accurate data and so broaden our knowledge of birds of this area.

The list includes a total of 285 species. The calendar graph on the left hand page is divided into the twelve months of the year; each month is divided into three sections indicating ten days each. In this way approximate dates are indicated. The graph itself is easy to read and should answer the question, "When is the bird found here?"

A solid line indicates a bird present, common to abundant. During summer months this indicates nesting.

Short, closely spaced dashes indicate the bird is here in limited numbers.

Long, widely spaced, dashes indicate the bird is here irregularly, or rarely. Dashed lines during summer months may or may not indicate nesting.

A separate dot indicates a specific record for the bird.

The habitat key following the name of each species should answer the question, "Where is the bird found?"

A. Aquatic

1. Open lakes and rivers
2. Marshes
3. Cattails and marsh borders

Asterisk (*) indicates additional species. See page 28.

B. Shrubs

1. Wet willow growth
2. Brushy hillsides
3. Woods borders
4. Forest undergrowth
5. Brushy creek banks

C. Forests

1. Bottomland
2. Maple-basswood
3. Oak-elm upland
4. Dry oak savannah
5. Conifer

D. Grassland

1. Wet sedge meadows
2. Grassy meadows
3. Dry uplands

E. Urban

F. Aerial

G. Cliffs and banks

H. Sandy beaches

I. Mud flats

The right hand page has been left for the observer to use in recording field trip observations.

The records on which the migration charts are based have been compiled from the files of the Museum of Natural History at the University of Minnesota, THE FLICKER, and THE BIRDS OF MINNESOTA, by Dr. T. S. Roberts. Special thanks are due to Mr. and Mrs. E. D. Swedenberg for the use of their personal records. The compilers want to thank Mrs. Helen Chapman of the Museum staff and Mrs. Margaret Ring of the Continental Machines Company of Savage for help in the mechanics of assembling this pamphlet.

Anne Winton Dodge   Walter J. Breckenridge
Helen Ford Fullerton   Dwain W. Warner

Table 4 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Loon	A1												
Red-throated Loon	A1												
Holboell's Grebe	A												
Horned Grebe	A1-2												
Eared Grebe	A1-2												
Pied-billed Grebe	A2-3												
White Pelican	A1												
Double-cr. Cormorant	A1												
Great Blue Heron	A2-3												
American Egret	A2-3												
Green Heron	A3, B-5												
Bl.-cr. Night Heron	A2-3, C-1												
American Bittern	A2-3												
Least Bittern	A3												
Whistling Swan	A1												
Canada Goose	A1-2												
White-fronted Goose	A1-2												
Snow-Blue Goose	A1-2												
Mallard	A												
Black Duck	A												
Gadwall	A												
Baldpate	A												
American Pintail	A												
Green-winged Teal	A												
Blue-winged Teal	A2-3												
Cinnamon Teal	A2-3												
Shoveler	A2-3												
Wood Duck													
Red head	A												
Ring-necked Duck	A												
Canvas-back	A												
Lesser Scaup Duck	A												
Greater Scaup Duck	A												
Golden-eye	A1												
Barrow's Golden eye	A1												
Buffle-head	A1												
Old Squaw	A1												
White-winged Scoter	A1												
Surf Scoter	A1												
American Scoter	A1												
Ruddy Duck	A2-3												
Hooded Merganser	A												
American Merganser	A												
Red-breasted Merganser	A												
Turkey Vulture	F												
Swallow-tailed Kite	F												
Goshawk	C												
Sharp-shinned Hawk	C												

Table 4. (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cooper's Hawk	C												
Red-tailed Hawk	F, C												
Red-shouldered Hawk	F, C												
Broad-winged Hawk	F, C												
Rough-legged Hawk	F, D												
Ferruginous Rough-leg	F, D												
Golden Eagle	F												
Bald Eagle	F												
Marsh Hawk	F, D												
Osprey	F, C												
Gyrfalcon	F, D												
Duck Hawk	F, G												
Pigeon Hawk	F, C												
Sparrow Hawk	F, D												
Ruffed Grouse	C												
Prairie Chicken	D												
Sharp-tailed Grouse	B, D												
European Partridge	D												
Bob-white	B2-3												
Ring-necked Pheasant	D												
Sandhill Crane	A2-D												
King Rail	A2-3												
Virginia Rail	A2-3												
Sora	A2-3												
Yellow Rail	D1-2												
Florida Gallinule	A2-3												
Coot	A												
Piping Plover	H												
Semipalmated Plover	I, H												
Killdeer	A, I, D												
Golden Plover	I, D, H												
Black-bellied Plover	I, D, H												
Ruddy Turnstone	H												
Woodcock	B1												
Wilson's Snipe	I, D-1												
Upland Plover	D2-3												
Spotted Sandpiper	I- H												
Solitary Sandpiper	I												
Western Willet	H-I												
Greater Yellow-legs	H- I												
Lesser Yellow-legs	H- I												
Knot	H												
Pectoral Sandpiper	H-I												
White-rumped Sandpiper	H-I												
Baird's Sandpiper	H-I												
Least Sandpiper	H- I												
Red-backed Sandpiper	H- I												
Dowitcher	H- I												

Table 4 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Stilt Sandpiper	H, I												
Semipalmated Sandpiper	H, I												
Buff-breasted Sandpiper	D, H, I												
Marbled Godwit	D, H, I												
Hudsonian Godwit	H, I												
Sanderling	H												
Avocet	H, I												
Wilson's Phalarope	DI- A												
Northern Phalarope	A, I												
Herring Gull	A, F												
Ring-billed Gull	A, F												
Franklin's Gull	A, D, F												
Bonaparte's Gull	A, F												
Forster's Tern	A												
Common Tern	A												
Least Tern	H, F												
Caspian Tern	F, A												
Black Tern	A												
Mourning Dove	D												
Rock Dove	E												
Yellow-billed Cuckoo	C												
Black-billed Cuckoo	C												
Screech Owl	C												
Great Horned Owl	C												
Snowy Owl	D												
Hawk Owl	C												
Barred Owl	C												
Great Gray Owl	C												
Long-eared Owl	C												
Short-eared Owl	D												
Saw-Whet Owl	C												
Whip-poor-will	C												
Night hawk													
Chimney Swift	F												
Ruby-th'd Hummingbird	CE												
Belted Kingfisher	C-1, G												
Flicker	C												
Pileated Woodpecker	C												
Red-bellied Woodpecker	C												
Red-headed Woodpecker	C												
Yellow-bellied Sapsucker	C												
Hairy Woodpecker	C												
Downy Woodpecker	C												
Artic 3-toed Woodpecker	C												
King bird	B-3, C-4, D												
Western Kingbird	C-4, D												
Crested Flycatcher	C												
Phoebe	C-1, B-3												

Table 4 (Continued).

Species	Hab.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Yellow-bellied Flycatcher	C												
Alder Flycatcher	BC												
Least Flycatcher	C												
Wood Pewee	C												
Olive-sided Flycatcher	C												
Horned Lark	D												
Tree Swallow	FB												
Bank Swallow	FG												
Rough-winged Swallow	FG												
Barn Swallow	EF												
Cliff Swallow	GE												
Purple Martin	EF												
Canada Jay	C												
Blue Jay	C												
Magpie	CB												
Raven	CF												
Crow	CF												
Black-capped Chickadee	C												
Hudsonian Chickadee	C5												
Tufted Titmouse	C												
White-breasted Nuthatch	C												
Red-breasted Nuthatch	C												
Brown Creeper	C												
House Wren	EC												
Winter Wren	B-4, C												
Bewick's Wren	C												
Carolina Wren	C												
Long-billed Marsh Wren	A3												
Short-billed Marsh Wren	DI												
Mockingbird	C												
Cat bird	CE												
Brown Thrasher	CE												
Robin	CE												
Wood Thrush	C												
Hermit Thrush	C												
Olive-backed Thrush	C												
Gray-cheeked Thrush	C												
Veery	C												
Bluebird													
Townsend's Solitaire	C												
Blue-gray Gnatcatcher	C												
Golden-crowned Kinglet	C												
Ruby-crowned Kinglet	C												
American Pipit													
Bohemian Waxwing	C												
Cedar Waxwing	C												
Northern Shrike	B-3, C-4, D												
Migrant Shrike	C-4, D												

Table 4 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Starling	E												
Bell's Vireo	CB												
Yellow-throated Vireo	C												
Blue-headed Vireo	C												
Red-eyed Vireo	C												
Philadelphia Vireo	C												
Warbling Vireo	C												
Black & White Warbler	C												
Prothonotary Warbler	C1												
Worm-eating Warbler	B4												
Golden-winged Warbler	B3												
Blue-winged Warbler	B2-3												
Tennessee Warbler	C												
Orange-crowned Warbler	C												
Nashville Warbler	C												
Parula Warbler	C												
Yellow Warbler	B2-3, E												
Magnolia Warbler	C												
Cape May Warbler	C												
Black-th'd Blue Warbler	C												
Myrtle Warbler	C												
Audubon's Warbler	C												
Black-th'd Green Warbler	C												
Cerulean Warbler	C2												
Blackburnian Warbler	C												
Hooded Warbler	B4												
Chestnut-sided Warbler	B3												
Bay-breasted Warbler	C												
Black-poll Warbler	C												
Pine Warbler	C												
Palm Warbler	CB												
Oven-bird	B4												
Northern Water-Thrush	B5												
Louisiana Water-Thrush	B5												
Connecticut Warbler	B4												
Mourning Warbler	B4												
Yellow-throat	A-3, B1												
Yellow-breated Chat	B2												
Wilson's Warbler	B3-4, C												
Canada Warbler	C												
Redstart	C												
English Sparrow	E												
Bobolink	D1												
Eastern Meadowlark	D												
Western Meadowlark	D												
Yellow-headed Blackbird	A3												
Red-winged Blackbird	A3												
Orchard Oriole	C3-4												

Table 4 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Baltimore Oriole	C												
Rusty Blackbird	C-1												
Brewer's Blackbird	D												
Bronzed Grackle	CDE												
Cowbird	BCDE												
Scarlet Tanager	C												
Cardinal	C												
Rose-breasted Grosbeak	C												
Indigo Bunting	B-2, 3												
Dickcissel	D-2												
Evening Grosbeak	C												
Purple Finch	C												
Pine Grosbeak	C-5												
Hoary Redpoll	D, B-2												
Redpoll	D, B-2												
Pine Siskin	C												
Goldfinch	CB												
Red Crossbill	C-5												
White-winged Crossbill	C-5												
Towhee	C												
Savannah Sparrow	D-2												
Grasshopper Sparrow	D-3												
Leconte's Sparrow	A3, D-1												
Henslow's Sparrow	A3, D-1												
Nelson's Sparrow	A3, D-1												
Vesper Sparrow	D-3												
Lark Sparrow	C-4, D-3												
Slate-colored Junco	C												
Oregon Junco	C												
Tree Sparrow	B, C-1												
Chipping Sparrow	B, C-5, E												
Clay-colored Sparrow	B-2, C-4												
Field Sparrow	B-2, C-4												
Harris's Sparrow	B-3, C												
White-crowned Sparrow	B-3, C												
White-throated Sparrow	C												
Fox Sparrow	C												
Lincoln's Sparrow	B-5, C												
Swamp Sparrow	A-3, B-1												
Song Sparrow	A3, B-1, 5												
Lapland Longspur	D												
Snow Bunting	D												
ADDITIONAL SPECIES													
Western Grebe	A												
Yel'cr Night Heron	A2-3, C1												
Western Tanager	C												

Table 5. Water Quality of Mississippi River Measured at the Intake of the Minneapolis Water Works in Fridley, 1973

Parameter		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Bacteria in	Total	108690	114270	7850080	221300	117730	109400	67690	117270
raw water,	Aver.	3506	4081	253228	7343	3797	3647	2184	2783
Most Prob.	Max.	13000	17000	7160000	35000	13000	24000	7900	17000
No./100 ml	Min.	790	490	700	1300	170	450	330	170
Turbidity,	Aver.	2.7	2.0	5.0	3.1	4.7	4.7	4.7	4.5
Jackson	Max.	3.1	2.4	14.0	4.0	20	9.0	24	10
Turbidity	Min.	1.9	1.5	1.9	2.5	2.9	3.3	3.3	2.2
Units									
Calcium	Aver.	119.4	125	96	106	107	107	104	94
Hardness	Max.	126	135	124	113	135	116	116	102
in mg/l	Min.	112	119	69	95	94	101	100	85
as $CaCO_3$									
Bicarbo-	Aver.	168	175	128	132	130	136	133	120
nate, mg/l	Max.	178	180	175	144	139	146	140	139
	Min.	153	170	88	118	113	128	125	98
Alkalin-	Aver.	168.2	179	132.5	144	140	146	148	135
ity, mg/l	Max.	177	188	182	154	151	153	155	232
as $CaCO_3$	Min.	155.5	172.5	91	126	125	134	137	120
pH	Aver.	7.90	8.1	8.02	8.4	8.2	8.21	8.5	8.4
	Max.	8.03	8.2	8.2	8.7	8.4	8.43	8.6	8.6
	Min.	7.75	7.95	7.75	8.05	8.0	8.0	8.3	8.1
Color	Aver.	28	24	48.7	44	51	59	47.7	56
	Max.	32	26	74	53	64	72	73	77
	Min.	25	20	20	38	45	47	40	37
Fluoride,	Aver.	0.15	0.12	0.14	0.15	0.17	0.19	0.18	0.17
mg/l	Max.	0.16	0.13	0.16	0.16	0.20	0.24	0.19	0.19
		0.15	0.5	0.13	0.13	0.13	0.15	0.16	0.15

Table 6. Turbidity, temperature and dissolved oxygen in the SAF Pools, Pools 1 and 2 of the Mississippi River the the Lower Minnesota River, November 1 and 2, 1973 (Colingsworth, Gudmundson and Weir)

Date	Pool	Transect	Depth in ft.	Turbidity** FTU	Temp., OC	DO, ppm	Remarks
1 Nov 73	USAF	Hd. Nicollet Is.	0'	4	8.5	8.67	
			12'(b)*	4			
		AA* (Mid-ch)†	0'	4	8.0	8.04	
			12'(b)	4	8.0	7.70	
		BB (Mid-ch)	0'	5.5	8.2	7.70	
			15'(b)	4	8.3	6.67	
		CC (E. ch)	0'	18	8.2	6.65	
			10'(b)	2	7.7	7.00	
		CC (Mid-main ch)	0'	2	5.8	9.17	
			25'(b)	3	5.2	9.53	
	LSAF	BB (R/B)††	0'	2	9.3	6.88	@Shiely
			14'(b)	4	8.6	7.50	
		BB	0'	2.5	8.7	7.17	1.5 Min after Joaljim pushed 2 loaded barges u/s to 'C' yd.
			14'(b)	4	8.0	7.00	
		BB (Mid-ch)	0'	3	7.5	8.06	
			10'	3.5	7.0	7.28	
		BB	0'	3	8.2	6.83	Underneath Stone Arch Br. center
			(b)	4	8.3	7.00	
	1		0'	4	8.3	8.00	
			13'(b)	4	7.5	9.54	
		AA (Mid ch)	0'	4	8.6	6.00	∿ 300' D/S from LSAF Dam, Mid ch.
			22'(b)	5	8.5	6.67	
		BB (Mid ch)	0'	4.5	8.4	6.13	
			18'(b)	5	8.3	6.20	
		CC (Mid)	0'	6	8.6	6.20	
			12'(b)	5	8.5	6.13	
	2	AA (Mid-main ch)	0'	4	8.6	7.50	
			18'(b)	5	8.6	9.33	
		AA (L ch mid)	0'	5	8.6	6.34	
			10'(b)	6	8.5	8.34	
	Minn.	CC (Mid-ch)	0'	42.5	9.3	6.18	
			15'(b)	56	7.0	8.82	
	2	St.P. ycht club	0'	11	8.6	5.67	
			12'(b)	12	9.0	8.78	
		Mile 831.1	0'	9	9.0	6.17	
			15"(b)	9	8.9	6.17	
		BB	0'	12	9.1	6.19	
			21'(b)	11	9.0	6.17	
2 Nov 73	Minn.	BB	0'	17.5	7.1	12.84	
			11'(b)	19.5	7.8	14.00	
		CC - R/B	0'	37			@R/B-no boat wake
			0'	46			
		- Mid ch	0'	33	8.6	7.67	@R/B-40 sec. after own boat wake (1/2 throttle ∿20' from R/B)
			15'(b)	36.5	8.5	7.83	

*(b) = river bottom depth † ch = channel †† R/B = right bank

**FTU = Formazine Turbidity Units; measured with a nephelometer.

Table 7. Downstream profile of turbidity (in FTU) and the effect of dredging and barge Traffic on Turbidity in the Minnesota River, September 25, 1973 (Colingsworth and Gudmundson)

(D') = water depth sampled, in feet.

MN.R. Mile	Location	Left Bank FTU	(D')	Mid-chan. FTU	(D')	Right Bank FTU	(D')	Notes
21.8	150 yds upstream from Peavey terminal	33 37 (bottom 3')	(0') (2')	36 42 (bottom 6')	(0') (4')	35 39 (bottom 7')	(0') (5')	Head of privately maintained nine-foot navigation channel.
21.7	130 yds downstream from Peavey terminal					31	(0')	ditto.
21.4	Sharp right bend	28	(0')			32	(0')	Left bank is on outside of bend, eroding.
19.5	Sharp right bend	21	(0')			23	(0')	Left bank is on outside of bend.
18.5	Sharp right bend	21	(0')			23	(0')	Left bank is on outside of bend.
16.8	Upstream from Co Hwy. 25 Brdg.	22	(0')			21	(0')	Right bank riprapped.
15.1	Upstream from Bunge terminal	21 25 (bottom 7')	(0') (5')	18 23 (bottom 12')	(0') (9')	22 27 (bottom 5')	(0') (3')	Upstream from heavy barge traffic.

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Continued)

Transect UAA, Mile 857.3 (Continued)

UAA: Mid-stream; Spring 1973; Coarse sand; 10 to 11', 12.3 maximum depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	67.

UAA: Mid-channel; Summer 1973; Rocks, sand and gravel, 7' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	22	64.
		Cheumatopsyche	6	
Ephemeroptera	Potamanthidae	*Potamanthus*	2	
	Heptageniidae	*Stenonema?* (damaged)	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	2	
		Rheotanytarsus	12	
	Pentaneurini		9	
		Polypedilum (pupa)	1	
	Tantytarsini (pupa)		2	
	Chironominae (unident. pupa)		1	
	Empididae	*Hemerodromia?*	4	
		Hemerodromia? (pupa)	2	
	Tipulidae	(unident. larva)	1	
	Simuliidae	*Simulium*	2	
		Simulium (pupa)	2	
	Chironomidae	*Rheotanytarsus ?*	1	

(in case, attached just behind head to cervical membrane of a Hydropsyche larva)

Table 8. Benthic Animal Abundance (cont.).

A

Comparison of Spring and Summper Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croxi Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Continued)

Transect UBB, Mile 855.7

UBB : Left bank; Spring 1973; no organisms in sample

UBB : Burlington Northern RR bridge; 3rd pier from L/B; Summer 1973; Sand,rocks; 14' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	49.
Diptera	Chironomidae	*Cryptochironomus*	2	

UBB : Mid-channel; Summer 1973; Medium coarse sand

Diptera	Chironomidae	*Polypedilum*	1	65.

UBB : Mid-channel; Summer 1973; Sand and fine gravel with some plant debris; 13.75' depth

Diptera	Chironomidae	*Paratendipes*	1	54.

UBB : Right bank; Spring 1973; 4" d. chunk of cemet, very little fine sand, medium coarse sand; 2.7' deep, 12 yards from right bank

Trichoptera	Hydropsychidae	*Cheumatopsyche*	22	5.
		Hydropsyche	5	
		Macronemum	2	
Diptera	Chironomidae		2	
	Empididae		1	
Coleoptera	Elmidae		1	
	Elmidae	(Adults)	3	

UBB : Right bank; Summer 1973; no organisms

A

Table 8. Benthic Animal Abundance (cont.)
Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Concluded)

Transect UCC; Mile 854.4

UCC: E, Left bank only; Spring 1973; Fine sand (on shelf), hardly any sediments; 16' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			1	73.

UCC: Ekman, Left Bank; Summer 1973; no sample

UCC: Ekman, Mid-channel; Spring 1973; no sample

UCC: Ekman, Mid-channel; Summer 1973; Sand and gravel; 10' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	2	53.
Coleoptera	Elmidae		5	
Diptera	Chironomidae	*Stictochironomus*	1	
		Polypedilum	1	
		Eukiefferiella	1	

UCC: Mid- main channel; Summer 1973; Coarse sand with numerous small clam-shells; 18.5 - 19' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	
		Polypedilum	4	
		Paratendipes	1	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Lower St. Anthony Falls Pool

Transect LBB, Mile 853.4

LBB: Left bank; Spring 1973; 10 yards from left bank, and 325 yards from right bank; medium coarse sand with silt, plant and shell fragments; 3' depth

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	3	69.
		Rheotanytarsus	1	

LBB: Left bank; Summer 1973; Sand, silt and pebbles; 3' deep

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Psychomyiidae	*Nyctiophylax*	3	
Ephemeroptera	Caenidae	*Caenis*		
	Heptageniidae	*Stenonema*	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Dicrotendipes*	8	
		Glyptotendipes	6	
		Polypedilum	2	
		Cryptochironomus	5	
		Psectrotanypus	1	
Oligochaeta			5	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota dn Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Lower St. Anthony Falls Pool (Concluded)

Transect LBB, Mile 853.4 (Continued)

LBB: Mid-channel; Spring 1973; A few pieces of bark, with Trichoptera larvae; 165 yards from Left bank and 155 yards from right bank, L guide wh

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	18	11.
		Hydropsyche (pupae)	2	
		Cheumatopsyche	9	
		Cheumatopsyche (pupae)	2	
	Philopotamidae	*Chimarra*	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Endochironomus*	1	
		Microtendipes	1	
		Polypedilum	1	
	Chironominae	(unident., very small larva)	1	

LBB: Mid-channel; Summer 1973; Sand and pebbles; 14' deep

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	
Oligochaeta			1	

LBB: Right bank; Spring 1973; Medium sand and silt (little current); 100 yards from right bank, 240 yards from left bank; 10' deep

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	17	
		Chironomus	1	
Oligochaeta			11	

LBB: Right bank; Summer 1973; no sample

Table 8. Benthic Animal Abundance (cont)
A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1

Transect 1AA, Mile 853.2

1AA: Left bank; Spring 1973; 62 yards from left bank and 127 yards from right bank; rocks with Trichoptera and 1 mayfly; 17.0' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	3	9.
		Cheumatopsyche	8	
Ephemeroptera	Potamanthidae	*Potamanthus*	1	
Diptera	Chironomidae	*Polypedilum*	2	

1AA: Left bank; Summer 1973; no sample

1AA: Mid-channel; Spring 1973; no sample

1AA: Mid-channel; Summer 1973; Coarse sand and gravel, rocks, fine sand; 11.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	
	Potamanthidae	*Potamanthus*	1	
Ephemeroptera	(Unident. damaged nymph)		1	
Trichoptera	Hydropsychidae	*Cheumatopsyche*	3	
	Psycomyiidae	(Unident. damaged larva)	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Polypedilum*	3	
		Cryptochironomus	2	
	Tanytarsini		2	
	Pentaneurini		4	

Table 8. Benthic Animal Abundance (cont.)
Comparison of Spring and Summer Samples of Benthic
Macroinvertebrates Collected in 1973 in the
A Minnesota and Lower St. Croix Rivers and Mile
815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

1AA: Right bank; Spring 1973; 20 yards to right bank and 145 yards to left bank; Rocks with 1 mayfly nymph; 13.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	4	7.
Plecoptera	Perlodidae	*Isoperla*	1	
Ephemeroptera	Heptageniidae	*Stenonema*	1	
Diptera	Chironomidae	*Polypedilum*	1	
	Orthocladiinae	(Unident. pupa)	1	

1AA: Right-bank; Summer 1973; no sample

Transect 1BB, Mile 850.6

1BB: Left-bank; Spring 1973; 8 yards to spoil on left bank, 225 yards to right bank tree; Rock, gravel, sand and silt; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	6.
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta	Tubificidae		12	

1BB : Left bank; Summer 1973; Fine sand, silt, rocks; 8.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta			3	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

Transect 1BB; Mile 850.6 (Continued)

1BB : Mid-channel; Spring 1973; 135 yards to left bank, 76 yards to right bank spoil and 54 more yards to base of bluff and tree; No record of substrate type; 15.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	17.
Diptera	Chironomidae	*Polypedilum*	3	
		Paratendipes	3	
	Ceratopogonidae ?	(Unident. larva)	1	
Pelecypoda (clams)	Sphaeriidae	*Sphaerium*	1	

1BB : Mid-channel; Summer 1973; No organisms

1BB: Right bank; Spring 1973; No sample

1BB : Right bank; Summer 1973; No sample

Transect 1XX, Mile 851.1

1XX : Left bank; Spring 1973; No sample

1XX : Left bank; Summer 1973; 150' from left bank; Sand and a couple bark fragments; 12.5' depth

Coleoptera	Elmidae	(damaged larva)	1	40.

1XX: Mid-channel; Spring 1973; no sample

1XX: Mid-channel; Summer 1973; Sand and bark fragments (pine), shell fragments; 14' depth

Diptera	Chironomidae	*Paratendipes*	5	24.
Pelecypoda (clams)		*Sphaerium*	1	
Gastropoda (snails)		*Planorbula* (not alive)	1	
Oligochaeta			1	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

Transect 1XX, Mile 851.1 (Continued)

1XX: Right bank; Spring 1973; No sample

1XX: Right bank; Summer 1973; 35' to right bank; Shell fragments and bark, gravel and coarse sand; 15.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	19.
Diptera	Chironomidae	*Cryptochironomus*	5	
		Polypedilum	2	
	Pentaneurini		1	
Pelecypoda (clams)	Unionidae	*Actinonaias*	1	

Transect 1CC, Mile 848.0

1CC: Left-bank; Spring 1973; 20 yards to left-bank; Fine sand, few 1" stones, sticks; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	23	16.
		Paratendipes	6	
		Phaenopsectra	6	
		Cryptochironomus	1	
		Chironomus	2	
	Psychodidae	*Psychoda*	1	
Oligochaeta			15	

1CC: Left bank; Summer 1973; 100' from left bank; Fine sand and silt, sewer smell in sediments; 4.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	1	46.
		Chironomus	2	
		Polypedilum	1	
Oligochaeta			1	

Table 8. Benthic Animal Abundance (cont.)
Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

A

MISSISSIPPI RIVER (Continued)

Pool 1 (Concluded)

Transect 1CC, Mile 848.0 (Continued)

1CC: Mid-channel; Spring 1973; No sample

1CC: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Chironomus*	3	23.
Oligochaeta			2	

1CC: Right bank; Spring 1973; No sample

1CC: Right bank; Summer 1973; No sample

Pool 2

Transect 2AA, Mile 847.4

2AA: East channel, Left bank; Spring 1973; 59 yards from left bank, 300 yards from right bank; Rocks; 9.1' depth

Trichoptera	Hydropsychidae	*Hydropsyche*	3	10.
		Cheumatopsyche	5	
	Hydropsychidae	(Unident. pupae)	9	
		(Damaged larvae)	2	
	Psychomyiidae	*Polycentropus*	1	
Ephemeroptera	Potamanthidae	*Potamanthus*	2	
Diptera	Chironomidae	*Phaenopsectra*	1	
	Tanytarsini		3	
Hirudinea (leeches)			1	

2AA: East channel; Summer 1973; 15 feet from island; Rocks and coarse gravel; 3.5-5.0' depth

Coleoptera	Elmidae		1	
Hirudinea (leeches)			3	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2AA, Mile 847.4 (Continued)

2AA:Rock Scrapings; Left channel, 15 feet from island; Rocks and coarse gravel 3.5-5.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Potamanthidae	*Potamanthus*	1	34.
Trichoptera	Psychomyiidae	*Polycentropus*	1	
Diptera	Chironomidae	*Dicrotendipes ?*	1	
	Chironomidae ? (unident. egg mass)		1	
Hirudinea (leech)			1	

2AA: Mid-channel; Spring 1973; No sample

2AA:Mid-channel by lock; Rock scrapings; Summer 1973; Rocks encrusted with algae, etc.

Diptera	Chironomidae	*Polypedilum*	1	59.

2AA: Right bank; Spring 1973; No organisms

2AA: Right bank; Summer 1973; no organisms

Transect 2BB, Mile 831.7

2BB: Left bank; Spring 1973; 30 yards from left bank; Gelatinous, with sand; 4.5' depth

Diptera	Chironomidae	*Polypedilum*	6	71.
		Phaenopsectra	6	
		Chironomus	1	
		Stitochironomus	1	
	Empididae	(Unident. larva)	1	

2BB: Left bank; Summer 1973; Mostly sludge, silt and organic clay; 11.1' depth

Diptera	Chironomidae	*Procladius*	6	35.
Oligochaeta			32	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2BB, Mile 831.7 (Concluded)

2BB: Mid-channel; Spring 1973; 10 yards from right bank and 250 yards to left bank; 23' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Plecoptera	Perlodidae	*Isoperla*	1	8.
Ephemeroptera	Ephemeridae	*Pentagenia*	1	
	Potamanthidae	*Potamanthus*	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Xenochironomus*	18	
	Pentaneurini		3	

2BB: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Chironomus*	4	29.
		Procladius	1	
	Chaoboridae	*Chaoborus*	6	
Oligochaeta			37	

2BB: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	60.

2BB: Right bank; Spring, 1973; No sample

2BB: Right bank; Summer 1973; No sample

Table 8. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Miscellaneous Pool 2 Sites

Pool 2: Right bank of back channel, Newport Island; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	47.
Oligochaeta				

Chute behind Island 2CC; Right-bank; Downstream from 827.7; Summer 1973; Clay, silt and some sand; 4' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta	(Many fragements)		47	28.
Nemertea (proboscis worm)			1	

Mile 827.7: Left bank backwater; Upstream from spoil; Summer 1973; Sand with 1/8" silt on top; 6.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	63.

Grey Cloud Slough at twin fill; Summer 1973; Organic mud; 18' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Tanypus*	2	31.
		Chironomus?	1	
	Chaoboridae	*Chaoborus*	7	

Baldwin Lake; Downstream from spoil; Summer 1973; About 1" of silt on 2' deep sand and mud

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	48.
Oligochaeta			4	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi Rivers (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2YY, Mile 821.4

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
2YY :"3A"; Spring 1973; 135 yards to right bank; Organic mud, much silt, some fine grit; 3.2' depth				
Diptera	Chironomidae	*Psectrotanypus*	1	1.
		Procladius	9	
		Cryptochironomus	1	
Oligochaeta	Tubificidae		54	
Oligochaeta		(Immatures and/or small)	23	
2YY :"3A"; Right-bank; Summer 1973; Soft mud; 3.5' depth				
Diptera	Chironomidae	*Procladius*	1	36.
Oligochaeta			5	
2YY :"3B"; Spring 1973; no sample				
2YY :"3B"; Summer 1973; Soft mud; 3' depth				
Diptera	Chironomidae	*Procladius*	3	41.
Oligochaeta			8	
2YY: "3C"; Spring 1973		Note: "3C" is mid-channel		
Diptera	Chironomidae	*Procladius*	19	15.
		Tanypus	2	
Oligochaeta			14	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix River and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Concluded)

Pool 2 (Concluded)

Transect 2YY, Mile 821.4 (Continued)

2YY:"3C"; Summer 1973; Medium coarse sand with 1/8" silt layer on top; 12.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	50.

Transect 2CC, Mile 815.5

2CC: Left bank; Spring 1973; 7 yards from left bank, 1 mile to right bank, 750 yards to upstream tip of Buck Island;Black clay mud (kept shape), sl anaerobic; 15.5' depth

Oligochaeta			94.	14.

2CC: Left bank; Summer 1973; No sample

2CC: Mid-channel; Spring 1973; 155 yards from left bank; 3 tries and Petersen dredge wouldn't trip, anchor came up with partly decayed leaves, sticks, large branch and sludge attached; 28' depth

Diptera	Chironomidae	*Procladius*	8	68.

2CC: Mid-channel; Summer 1973

Diptera	Chironomidae	*Procladius*	8	27.
Oligochaeta			11	

2CC: Right bank; Spring 1973; No sample

2CC: Right bank; Summer 1973; No sample

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER

Transect MAA, Mile M24.8

MAA : Left Bank; Spring 1973; No organisms

MAA: Left bank; Rock Scrapings; Summer 1973; 40' from left bank; 1-2" silt over gelatinous mud, smelled slightly of decay; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	21.
	Hydropsychidae	(Unident. damaged pupa)	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Glyptotendipes*	9	
		Glyptotendipes (pupae)	2	
	Nematocera	(Unident. damaged pupae)	2	

MAA: Mid-channel; Spring 1973; No sample

MAA: Mid-channel; Summer 1973; No sample

MAA: Right bank; Spring 1973; No sample

MAA: Right bank; Summer 1973; No organisms

Transect MBB, Mile M13.0

MBB : Left bank; Spring 1973; No organisms

MBB: Left bank; Summer 1973; 6' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	57.

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER (Continued)

Transect MBB, Mile M13.0 (Continued)

MBB: Mid-channel; Spring 1973; No sample

MBB: Mid-channel; Summer 1973; No record of substrate; 8' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Tanypus*	2	25.
		Procladius	5	
Oligochaeta			11	

MBB: Right bank; Spring 1973; 12 yards from right bank; 120 yards from left bank; Coarse sand and clay pellets; 7.5' depth

Diptera	Chironomidae	*Cryptochironomus*	1	18.

MBB: Right bank; Summer 1973; Fine sand with clay lumps, silt layer on top; 3' depth

Diptera	Chironomidae	*Cryptochironomus*	1	18.

MBB: Right bank; Summer 1973; Fine sand with clay lumps, silt layer on top; 3' depth

Oligochaeta			1	51.

Transect MCC, Mile M3.0

MCC: Left-bank; Spring 1973; No organisms

MCC: Left-bank; Summer 1973; No sample

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St.Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER (Concluded)

Transect MCC, Mile M3.0 (Continued)

MCC: Mid-channel; Spring 1973; No sample

MCC: Mid-channel; Summer 1973; Fine sand with shallow layer of silt; 12' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	30.
Oligochaeta			28	

MCC: Right bank; Spring 1973; Ekman dredge (small amount of sand, much water) 5 yards to right bank; 5' depth

Oligochaeta			1	72.

MCC: Right bank; Summer 1973; Clay silt and some sand; 4' depth

Oligochaeta			9	38.

ST. CROIX RIVER

Transect SAA, Mile SC24.8

SAA: Left bank; Spring 1973; 10 yards to left bank; Substrate not recorded; 9.5' depth

Oligochaeta			1	78.

SAA: Left bank; Summer 1973; No sample

Table 8. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SAA, Mile SC24.8 (Continued)

SAA: Mid-channel; Spring 1973; Substrate not recorded; 5.2' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Micropsectra*	1	70.
	Ceratopogonidae ?	(Unident. larva)	1	
Oligochaeta			1	

SAA: Mid-channel; Summer 1973; Clay and mud (organic?); 1 chironomid; 22' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Tipulidae		1	22.
	Chironomidae	*Xenochironomus*	4	

SAA; Right bank; Spring 1973; No sample

SAA: Right bank; Mid backwater; Summer 1973; Fine sand overlain with silt; Middle of bay; 3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	33.

Transect SXX, Mile SC16.0

SXX: Left bank; Spring 1973; 560 yards from left bank; Shallows; 10.3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	74.
Diptera	Chironomidae	*Cryptochironomus*	2	
		Potthastia	1	
Oligochaeta			1	

SXX: Left bank; Summer 1973; Medium to fine sand, wood fragments and clam-shell; Middle of the bay; 7.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
[illegible]	Chironomidae	*Cryptochironomus*	1	43.
	Chaoboridae	*Chaoborus*	1	

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 in the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SXX, Mile SC 16.0 (Continued)

SXX: Mid-channel; Spring 1973; 1000 yards from left bank, 180 yards from right bank; Coarse red sand; 16.3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	75.
		Stictochironomus	1	
		Paracladopelma	1	
		Paracladopelma? (very small)	2	
Pelecypoda (clams)		*Pisidium*	10	
Gastropoda (snails)		*Stagnicola ?* (very small)	1	

SXX : Mid-channel; Summer 1973; No record of substrate; 15.7' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	39.

SXX: Right bank; Spring 1973; No sample

SXX: Right bank; Summer 1973; No sample

Transect SBB, Mile SC 12.3

SBB: Left bank; Spring 1973; No organisms

SBB: Left bank; Summer 1973; No organisms

SBB: Mid-channel; Spring 1973; No sample

SBB: Mid-channel; Summer 1973; No organisms

Table 8. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 in the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SBB, Mile (Continued)

SBB : Right Bank; Spring 1973; 1400 yards from left bank, 40 yards from right bank; Clams, snails, gravel to 5", coarse sand; 11.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Eggs (?) of unknown organism on pebble				
Diptera	Chironomidae	*Tanytarsini*	2	4.
Oligochaeta	Lumbriculidae		1	
Nematoda (roundworms)			1	

SBB: Right bank; Summer 1973; No sample

Transect SYY, Mile SC 6.4

SYY: Left bank; Spring 1973; Fine sand, sticks and plant debris; Backwater; 2.2 yards from right-bank; 3.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	5	3.
		Chironomus	8	
		Paratenaipes	7	
		Psectrotanypus	1	
		Procladius	8	
		Micropsectra	3	
		Harnischia	1	
		Polypedilum	4	
		Cladotanytarsus (most very small)	46	
	Ceratopogonidae	*Palpomyia ?*	3	
Oligochaeta	Tubificidae		2	

SYY: Left bank; Shallow; Summer 1973; Just downstream from Mo. and Kinnikinnick; Sand with a little silt; 3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	52.
		Polypedilum	2	
	Tanytarsini		1	
Oligochaeta			2	

Table 8. Benthic Animal Abundance (cont.)

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SYY, Mile SC6.4 (Continued)

SYY: Mid-channel; Spring 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Odonata	Gomphidae	(Unident. small nymph)	1	12.
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	2	
		Cryptochironomus	2	
	Ceratopogonidae	*Palpomyia*	1	
Oligochaeta			123	

SYY: Kinny mid-channel; Summer 1973; Medium to fine sand; 15.3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			1	44.

SYY: Right bank; Spring 1973; 12 yards from right bank; 1-2" stones, very little coarse sand; Depth not recorded

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae		1	76.
Egg? (of a fish?)			1	

SYY: Right bank; Summer 1973; About 30' from right bank; Rocks, pebbles, sand and plant debris; 14.5-15' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Glyptotendipes*	1	55.
		Glyptotendipes (pupa)	1	

Transect SCC, Mile ________

SCC: Left bank; Spring 1973; 30 yards from left bank, 700 yards from right bank; 12' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	77.

SCC: Left bank; Summer 1973; No sample

Table 8. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Concluded)

ST. CROIX RIVER (Concluded)

Transect SCC, Mile (Continued)

SCC: Mid-channel; Spring 1973; No sample

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera		(Unident. fragments)	1	62.
Oligochaeta			1	
Nemertea (proboscis worm)			1	

SCC: Right bank; Spring 1973; 5 yards from right bank; 1 rock 3" x 6" with worm-like encrustations; 3.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	66.

SCC: Right bank; Summer 1973; No sample

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates*of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973. (Arranged alphabetically within phyla).

List of Abbreviations

AA,BB,CC	Standard transects, in downstream order
XX,YY	Special Transects, in downstream order
U,L,1,2	Upper and lower St. Anthony Falls Pools, and Pools 1 and 2, respectively
M, S	Minnesota and St. Croix Rivers, respectively
Spr	Spring: April and May
Su	Summer: August and September
D/S, U/S	Downstream, upstream
ch	Channel
19.	Serial number of sample

PHYLUM NEMERTEA Proboscis worms

2CC Su 28. SCC Su 62.

PHYLUM NEMATODA Roundworms

SBB Spr 4.

PHYLUM ANNELIDA Segmented worms

Class Hirudinea Leeches

2AA Spr 10. 2AA L Ch 34. 2AA L ch Su 45.

Class Oligochaeta Aquatic earthworms

Family Lumbriculidae

SBB Spr 4.

Family Tubificidae

2YY Spr 1. 3YY Spr 3. 1BB Su 6.

Unidentifiable oligochaetes

SYY	Spr	12.	LBB	Spr	13.	2CC	Spr	14.	2YY	Spr	15.
1CC	Spr	16.	1XX	Su	24.	1CC	Su	23.	MBB	Su	25.
1BB	Su	26.	2CC	Su	27.	2CC	Su	28.	2BB	Su	29.
MCC	Su	30.	2BB	Su	35.	2YY	Su	36.	LBB	Su	37.
MCC	Su	38.	SXX	Su	39.	SYY	Su	44.	1CC	Su	46.

*Benthic macroinvertebrates: bottom-dwelling nonmicroscopic animals without backbones.

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973. (Continued).

PHYLUM ANNELIDA Segmented worms (Continued)

Class Oligochaeta (Continued)

Unidentifiable oligochaetes (Continued)

2	Su	47.	2	Su	48.	2YY	Su	50.	MBB	Su	51.
SYY	Su	52.	LBB	Su	58.	2BB	Su	60.	SCC	Su	62.
2		63.	SAA	Spr	70.	MCC	Spr	72.	UCC	Spr	73.
SXX	Spr	74.	SAA	Spr	78.	2YY	Su	41.			

Immatures and/or small Oligochaeta

2YY Spr 1.

PHYLUM ARTHROPODA Crustaceans, Insects and Spiders

Class Insecta Insects

Order Coleoptera Beetles

Family Elmidae

UBB	Spr	5.	2BB	Spr	8.	LBB	Spr	11.	SYY	Spr	12.
LBB	Spr	13.	1BB	Spr	17.	UAA	Su	20.	MAA	Su	21.
1AA	Su	32.	LBB	Su	37.	1XX	Su	40.	2AA	Su	45.
UCC	Su	53.	UAA	Su	64.	SCC	Spr	66.	SCC	Spr	77.

Order Diptera Flies, Mosquitoes and Midges

Family Ceratopogonidae (?) Unident. larva
1BB Spr 17.

Family Ceratopogonidae

Genus *Palpomyia (?)*
SYY Spr 3.

Genus *Palpomyia*
LBB Spr 13.

Family Chaoboridae

Genus *Chaoborus*

2BB	Su	29.	2*	Su	31.	SXX	Su	43.

*Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (?) Unident. larva

SAA	Spr	70.

Family Chironomidae (?) Unident. egg mass

2AA		34.

Family Chironomidae Unident. pupae

UAA	Su	20.	UAA	Su	64.

Family Chironomidae

Subfamily Chironominae

LBB	Spr	11.

Genus *Chironomus*

SYY	Spr	3.	LBB	Su	13.	1CC	Spr	16.	UAA	Su	20.
1CC	Su	23.	2BB	Su	29.	2*	Su	31.	1CC	Su	46.
2BB	Spr	71.									

Genus *Cladotanytarsus*

SYY	Spr	3.

Genus *Cryptochironomus*

2YY	Spr	1.	SYY	Spr	3.	1BB	Su	6.	SYY	Spr	12.
1CC	Spr	16.	MBB	Spr	18.	1XX	Su	19.	1BB	Su	26.
1BB	Su	32.	LBB	Su	37.	UCC	Su	42.	SXX	Su	43.
1CC	Su	46.	UBB	Su	49.	SYY	Su	52.	LBB	Su	58.
SXX	Spr	74.									

Genus *Diamesa*

SYY	Spr	76.

Genus *Dicrotendipes (?)*

2AA		34.

Genus *Dicrotendipes*

LBB	Su	37.

*Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Endochironomus*

LBB	Su	11.									

Genus *Eukiefferiella*

UCC	Su	53.									

Genus *Glyptotendipes*

MAA	Su	21.	LBB	Su	37.	SYY	Su	55.			

Genus *Harnischia*

SYY	Spr	3.									

Genus *Micropeectra*

SYY	Spr	3.	SAA	Spr	70.						

Genus *Microtendipes*

LBB	Su	11.									

Subfamily Orthocladiinae

1AA	Su	7.									

Genus *Paracladopelma*

SXX	Spr	75.									

Genus *Paratendipes*

SYY	Spr	3.	1CC	Spr	16.	1BB	Spr	17.	1XX	Su	24.
UCC	Su	42.	UBB	Su	54.						

Genus *Pentaneurini*

UBB	Spr	5.	2BB	Spr	8.	1XX	Su	19.	UAA	Su	64.
1AA	Su	32.									

Genus *Phaenopsectra*

2AA	Spr	10.	1CC	Spr	16.	2BB	Spr	71.			

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Polypedilum*

UAA	Spr	2.	SYY	Spr	3.	1AA	Spr	7.	1AA	Spr	9.
LBB	Spr	11.	SYY	Spr	12.	LBB	Spr	13.	1CC	Spr	16.
1BB	Spr	17.	1XX	Su	19.	UAA	Su	20.	1AA	Su	32.
LBB	Su	37.	UCC	Su	42.	1CC	Su	46.	SYY	Su	52.
UCC	Su	53.	MBB	Su	57.	2AA	Su	59.	UAA	Su	64.
UBB	Spr	65.	UAA	Spr	67.	LBB	Spr	69.	2BB	Spr	71.
SXX	Spr	75.									

Genus *Polypedilum* (pupa)

UAA	Spr	64.

Genus *Potthastia*

SXX	Spr	74.

Genus *Procladius*

2YY	Spr	1.	SYY	Spr	3.	2YY	Spr	15.	MBB	Su	25.
2CC	Su	27.	2BB	Su	29.	MCC	Su	30.	SAA	Su	32.
2BB	Su	35.	2YY	Su	36.	2YY	Su	41.	2*	Su	47.
2**	Su	48.	2CC	Spr	68.						

Genus *Psectrotanypus*

2YY	Spr	1.	LBB	Su	37.	SYY	Spr	3.

Genus *Rheotanytarsus (?)*

UAA	Spr	64.

Genus *Rheotanytarsus*

UAA	Spr	20.	LBB	Su	69.	UAA	Su	64.

Genus *Stictochironomus*

UCC	Su	53.	2BB	Spr	71.	SXX	Spr	75.

Genus *Tanypus*

2YY	Spr	15.	MBB	Su	25.	2†	Su	31.

*Right bank in West channel, Newport Island, mile 831.0.
**Baldwin Lake.
†Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Tanytarsini*

SBB	Spr	4.	2AA	Su	10.	1AA	Su	32.	SYY	Su	52.
UAA	Su	64.									

Genus *Xenochironomus*

2BB	Spr	8.	SAA	Su	22.

Family Empididae (Unident. larva)

UAA	Su	64.	2BB	Spr	71.

Family Empididae

UBB Spr 5.

Genus *Hemerodromia (?)*

UAA Su 20. UAA Su 64. Both samples also contain a pupa

Family Nematocera (Unident. damaged pupa)

MAA Su 21.

Family Psychodidae

Genus *Psychoda*

1CC Spr 16.

Family Simuliidae (very small larvae)

UAA Spr 2.

Family Simuliidae

Genus *Simulium*

UAA Su 64.

Genus *Similum* (pupa)

UAA Su 64.

Family Tipulidae

SAA Su 22.

Diptera (unident. fragment)

SCC Su 62.

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Ephemeroptera Mayflies

Family Caenidae

Genus *Caenis*

UAA	Su	20.	1AA	Su	32.	LBB	Su	37.	SXX	Spr	74.
UBB	Su	49.									

Family Ephemeridae

Genus *Pentagenia*

2BB	Spr	8.

Family Heptageniidae

Genus *Stenonema*

1AA	Spr	7.	UAA	Su	64.	LBB	Su	37.

Family Potamanthidae

Genus *Potamanthus*

2BB	Spr	8.	1AA	Spr	9.	2AA	Spr	10.	1AA	Su	32.
2AA		34.	UAA	Su	64.						

Order Odonata Dragonflies and Damselflies

Family Gomphidae (Unident. small nymph)

SYY	Spr	12.

Order Plecoptera Stoneflies

Family Chloroperlidae

Genus *Hastaperla*

UAA	Spr	2.

Family Perlodidae

Genus *Isoperla*

1AA	Spr	7.	2BB	Spr	8.

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Plecoptera (Continued)

Family Perlidae

Genus *Paragentina*

UAA	Spr	2.									

Genus *Phasganophora*

UAA	Spr	20.									

Order Trichoptera Caddis Flies

Family Hydropsychidae

Genus *Cheumatopsyche*

UAA	Spr	2.	UBB	Spr	5.	1BB	Spr	6.	1AA	Spr	9.
2AA	Spr	10.	LBB	Spr	11.	1XX	Su	19.	UAA	Su	20.
MAA	Su	21.	UCC	Su	53.	1BB	Su	26.	1AA	Su	32.
UAA	Su	64.									

Genus *Hydropsyche*

UAA	Spr	2.	UBB	Spr	5.	1AA	Spr	7.	1AA	Spr	9.
2AA	Spr	10.	LBB	Spr	11.	UAA	Su	20.	UAA	Su	64.

Genus *Macronemum*

UBB	Spr	5.	UAA	Spr	20.						

Family Hydropsychidae (Unidentified pupae; some damaged)

2AA	Spr	10.	UAA	Su	20.	MAA	Su	21.			

Family Hydropsychidae (Damaged or very immature)

UAA	Spr	2.									

Family Philopotamidae

Genus *Chimarra*

LBB	Spr	11.									

Table 8. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Trichoptera (Continued)

Family Psychomyiidae

Genus *Nyctiophylax*
LBB Su 37.

Genus *Polycentropus*
2AA Spr 10. 2AA 34.

Order Trichoptera (Unidentified very small larva)
UAA Spr 20.

PHYLUM MOLLUSCA Snails and Clams

Order *Gastropoda*

Family *Lymnaeidae*

Genus *Stagnicola (?)* (Very small)
SXX Spr 75.

Order Pelecypoda

Family Unionidae

Genus *Actinonaias*
1XX Su 79.

Family Sphaeriidae

Genus *Pisidium*
SXX Spr 75.

Genus *Sphaerium*
1BB Spr 17. 1XX Su 24.

EGGS (?) of unknown organism on pebble
SBB Spr 4.

EGG(?) of a fish
SYY Spr 76.

AD-A110 144 NORTH STAR RESEARCH INST MINNEAPOLIS MN ENVIRONMENTAL--ETC F/G 13/2
ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0059

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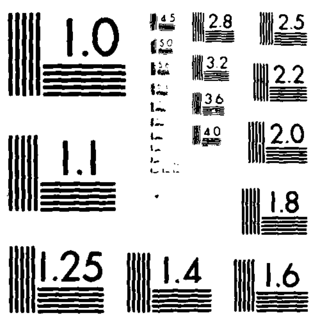

MICROCOPY RESOLUTION TEST CHART
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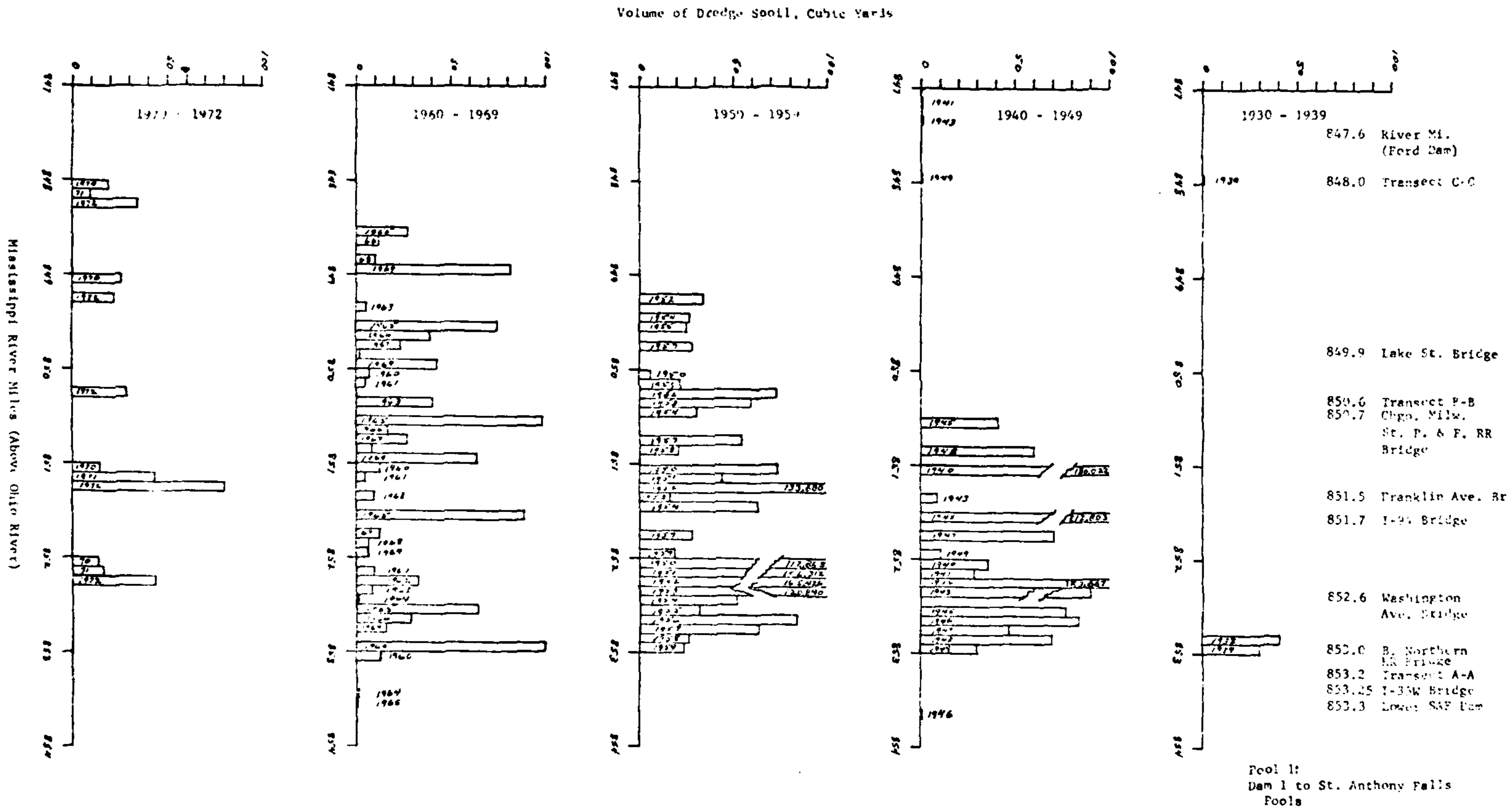

Figure 1. Annual Volume of Sediment Dredged Within Each River Mile of the Minnesota River, Arranged by Decade (S.P.D.-NCS, 1973).

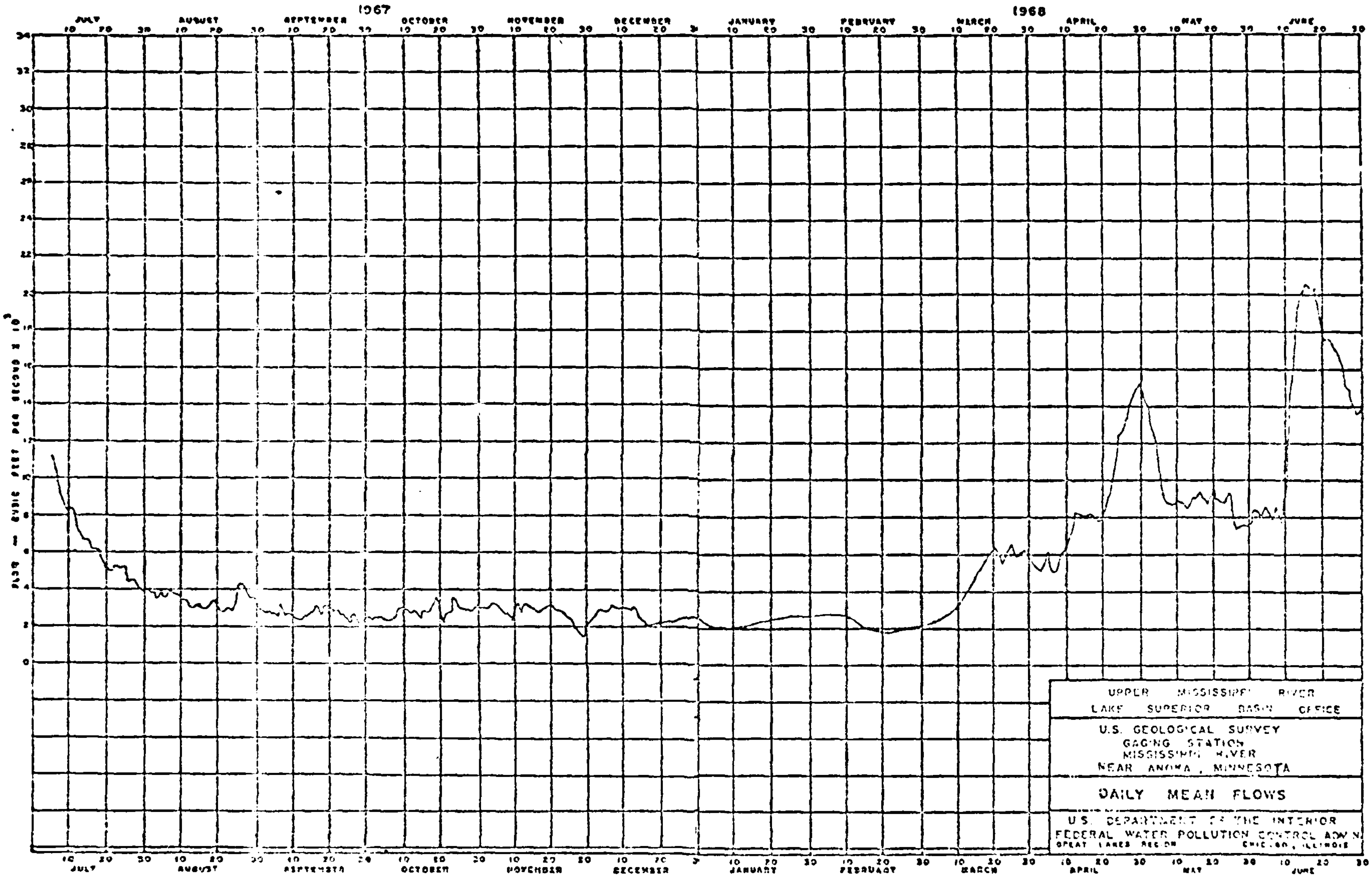

Figure 2. Daily Mean Flow of the Mississippi River at the Gaging Station Near Anoka, Minnesota During a Two Year Period (EPA).

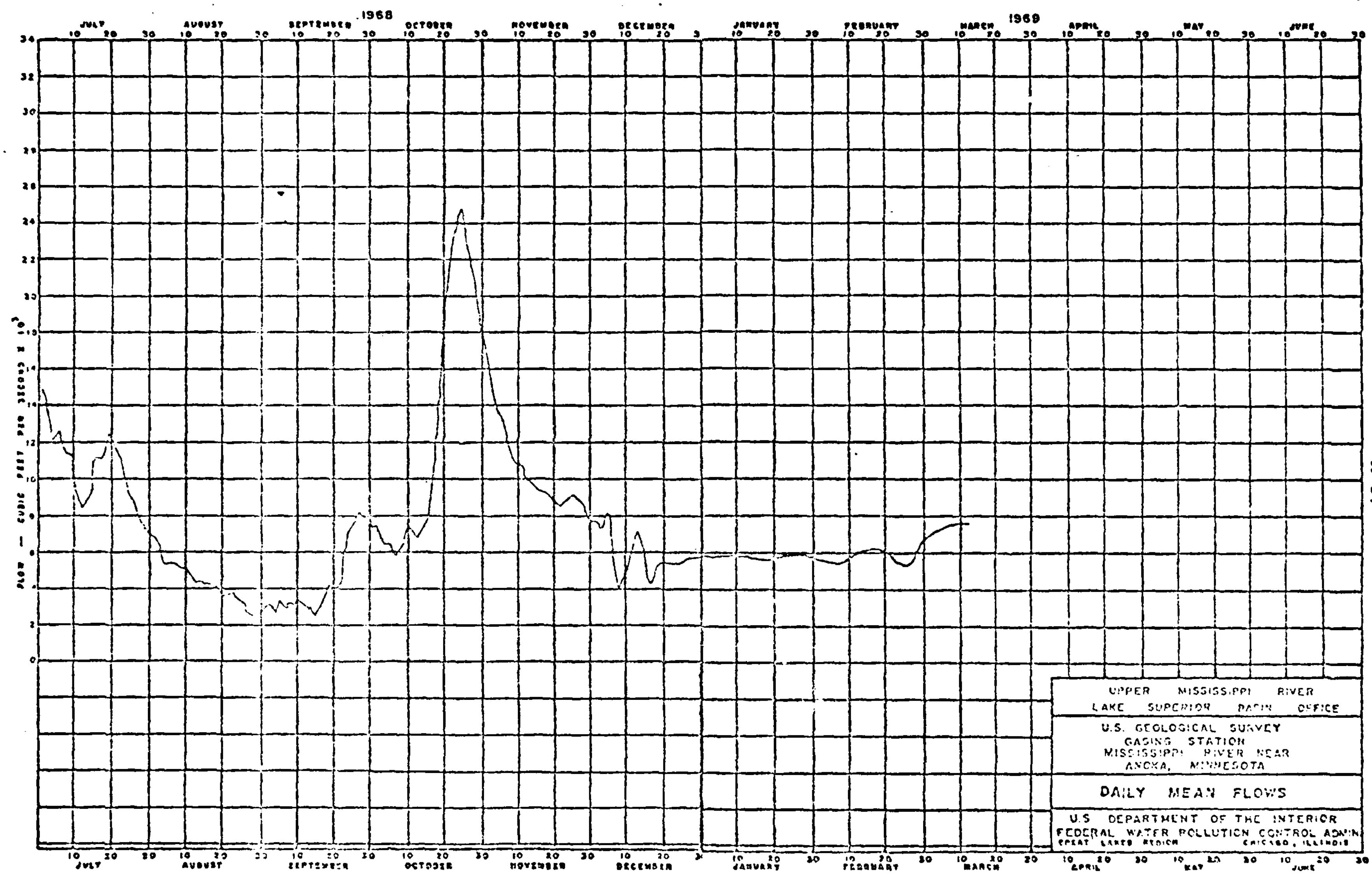

Figure 2. Daily Mean Flow of the Mississippi River at the Gaging Station Near Anoka, Minnesota During a Two Year Period (Continued).

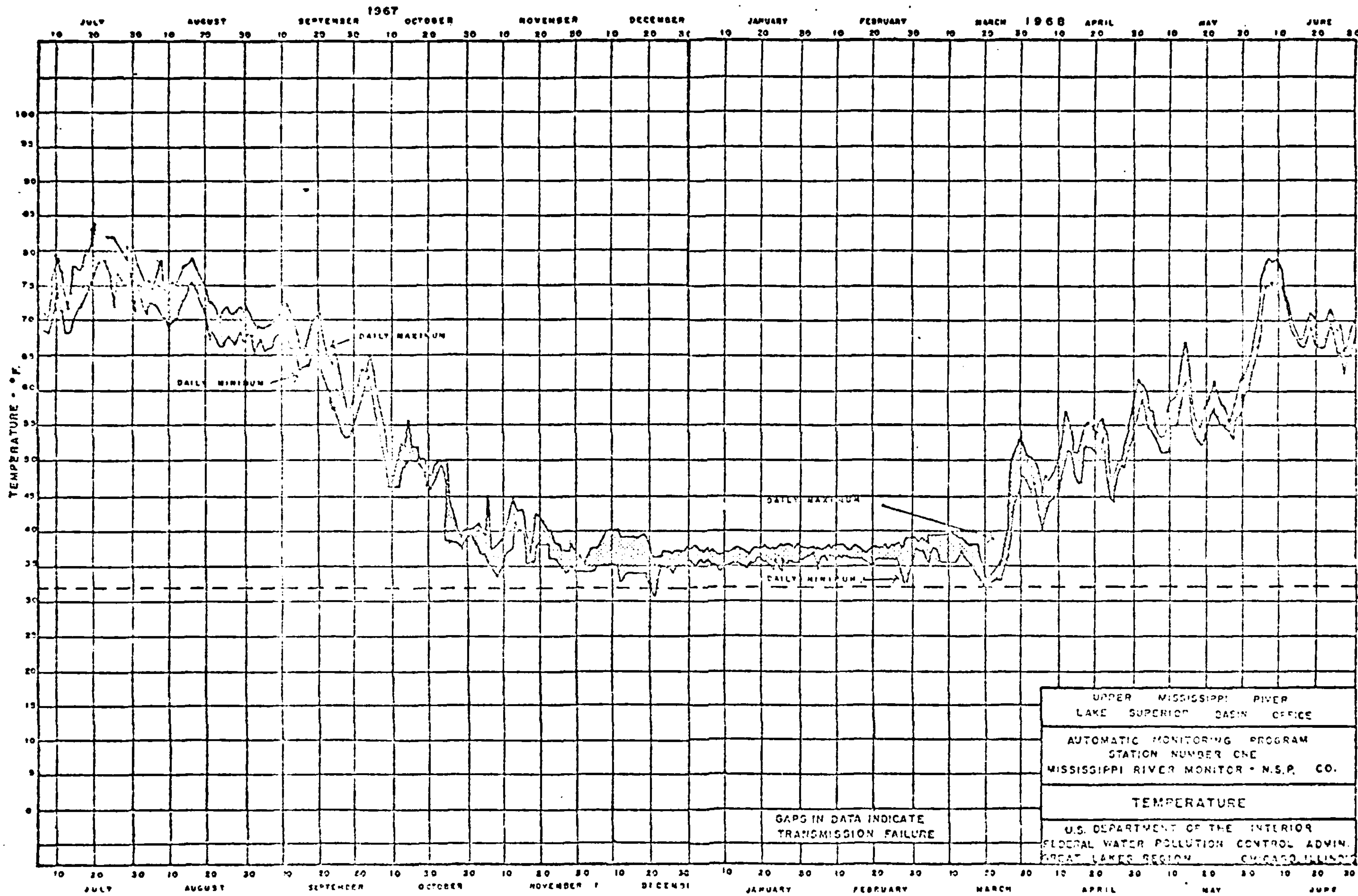

Figure 3. Seasonal Changes in Temperature Measured At Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (FWPCA).

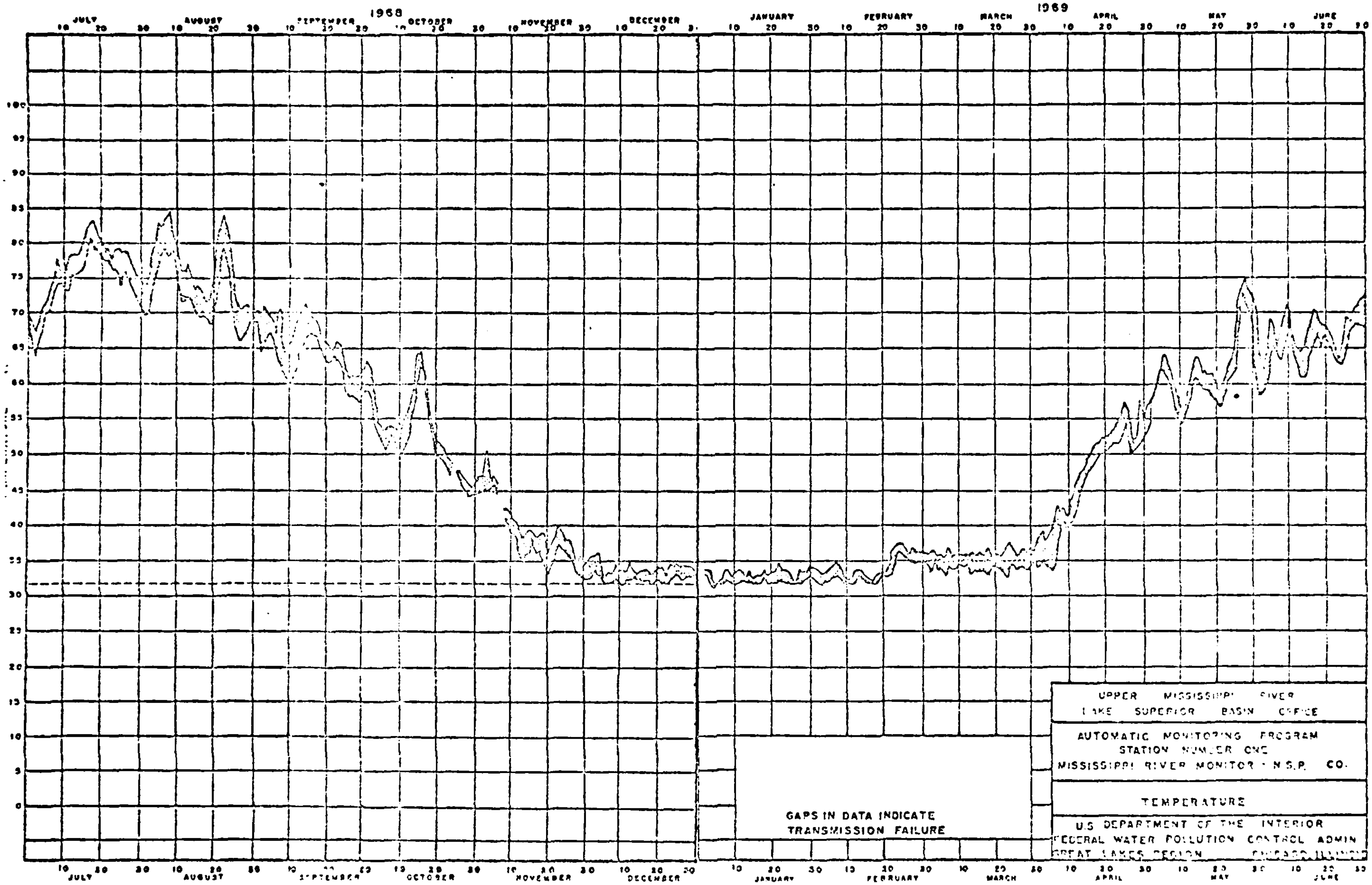

Figure 3. Seasonal Changes in Temperature Measured at Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (Continued).

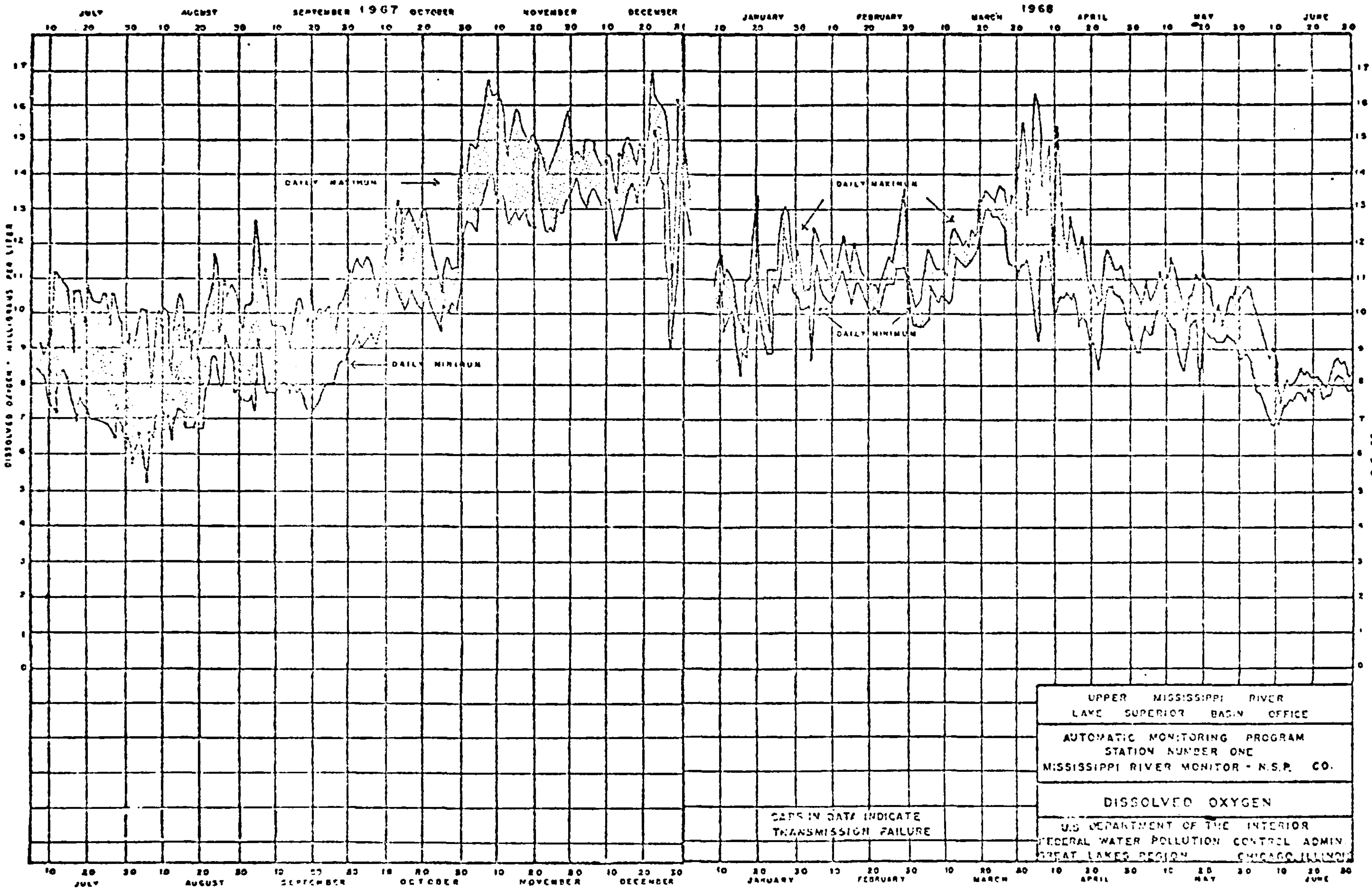

Figure 4. Seasonal Changes in the Dissolved Oxygen Measured at Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (FWPCA).

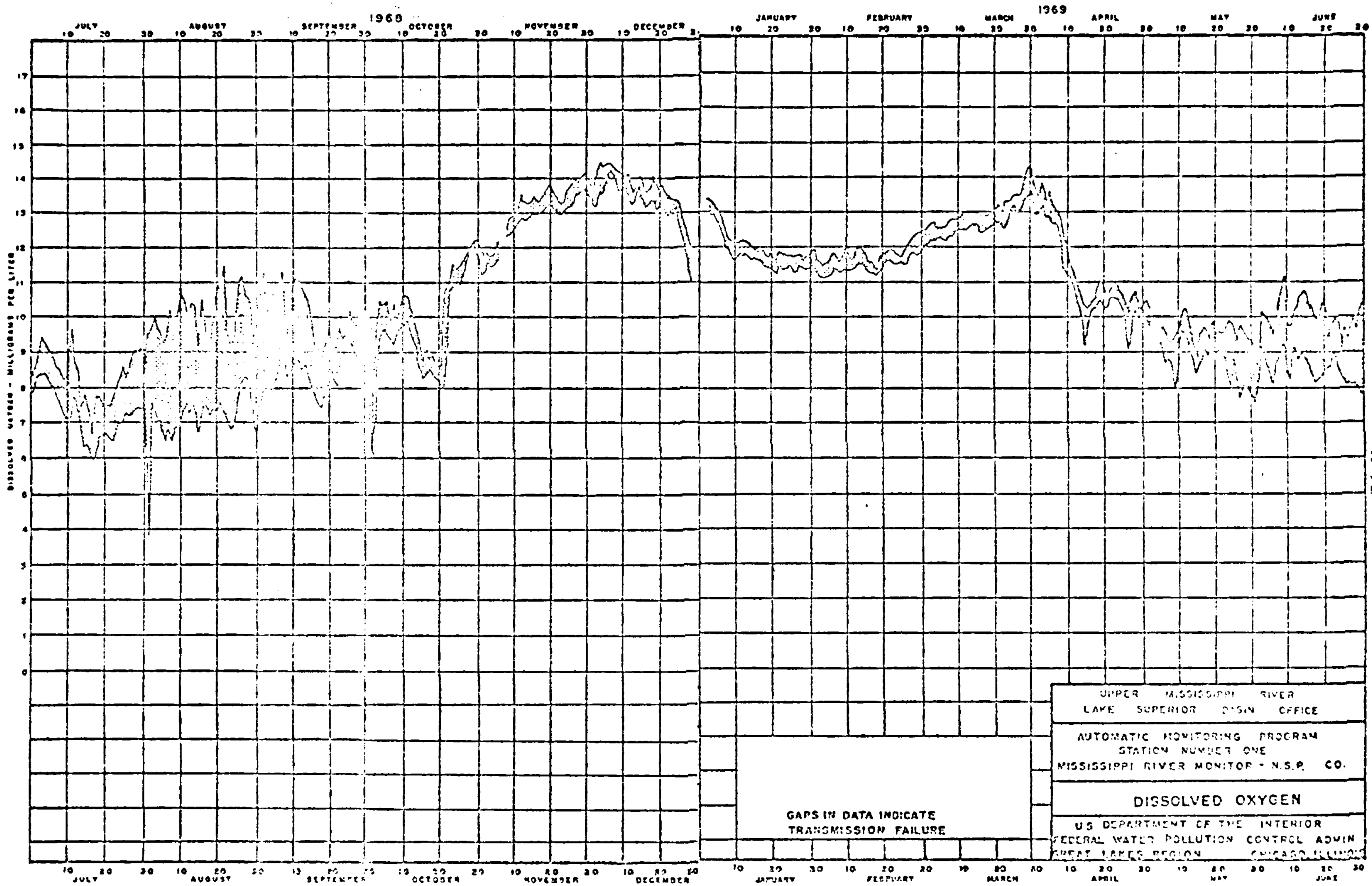

Figure 4. Seasonal Changes in the Dissolved Oxygen Measured at Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (Continued).

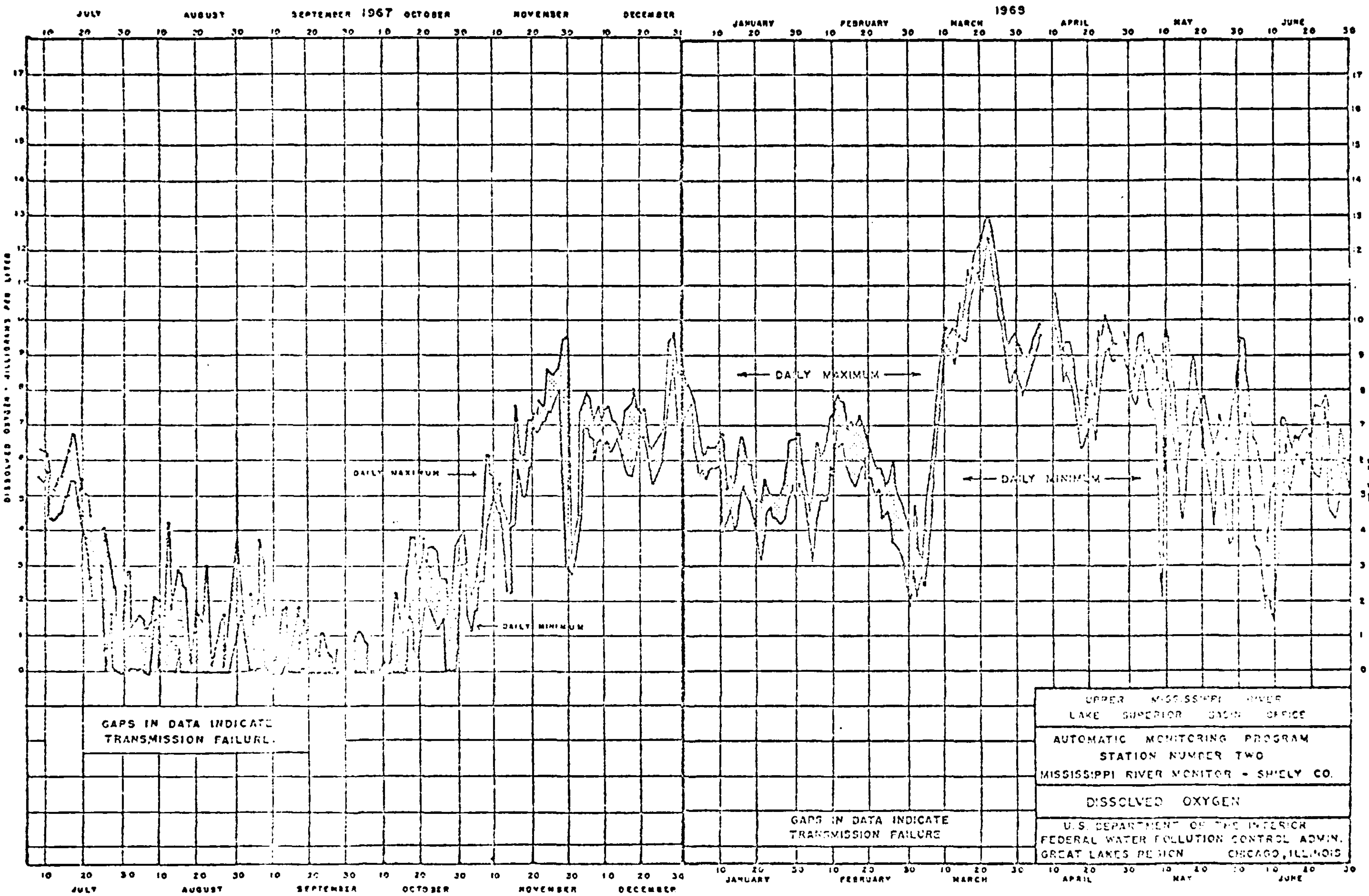

Figure 5. Seasonal Changes in the Dissolved Oxygen Measured at Station 2 Mile 826.6 on the Mississippi River During a Two Year Period (FWPCA).

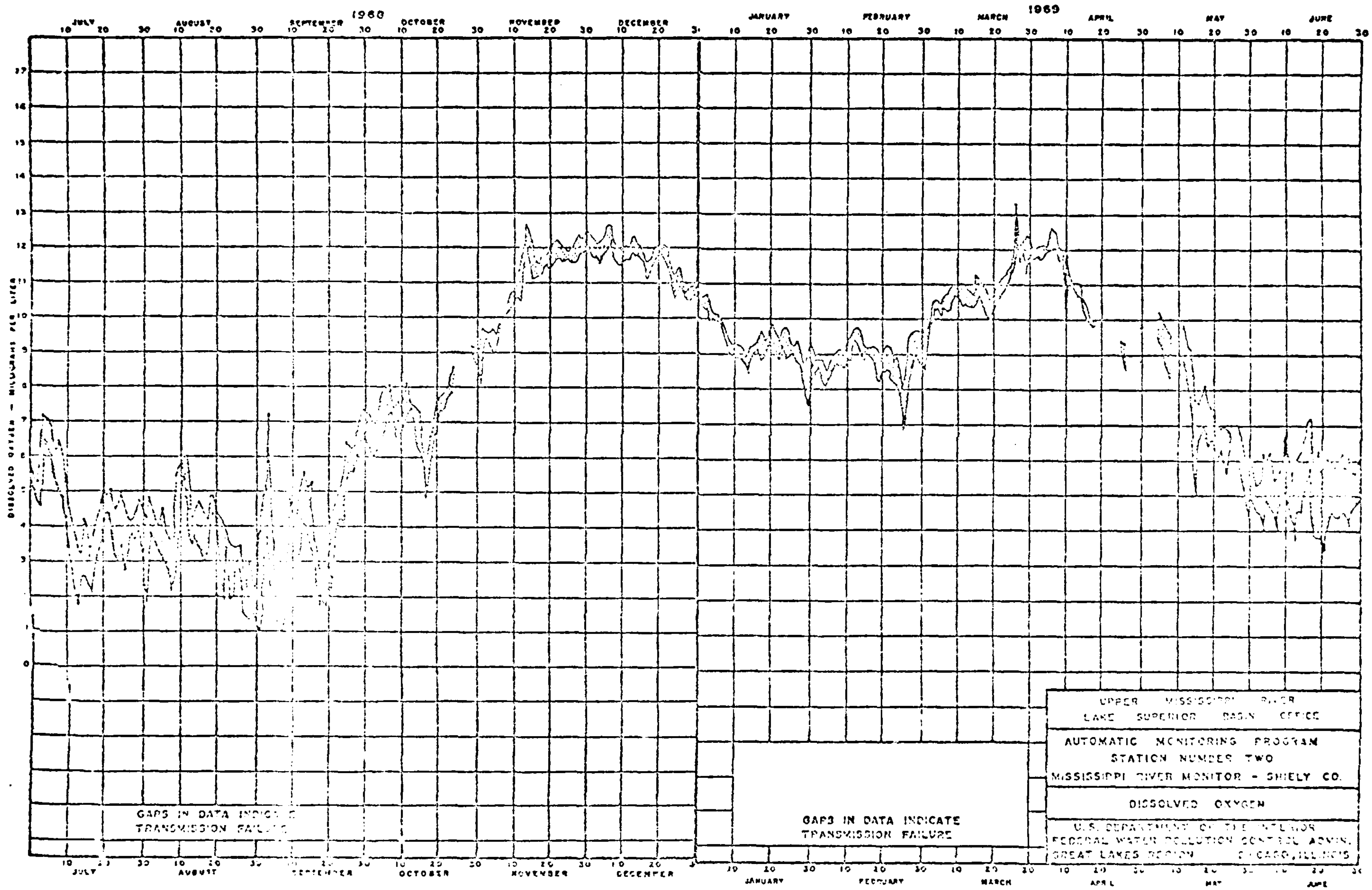

Figure 5. Seasonal Changes in Specific Conductance Measured at Station 1 Mile 826.6 on the Mississippi River During a Two Year Period (Continued).

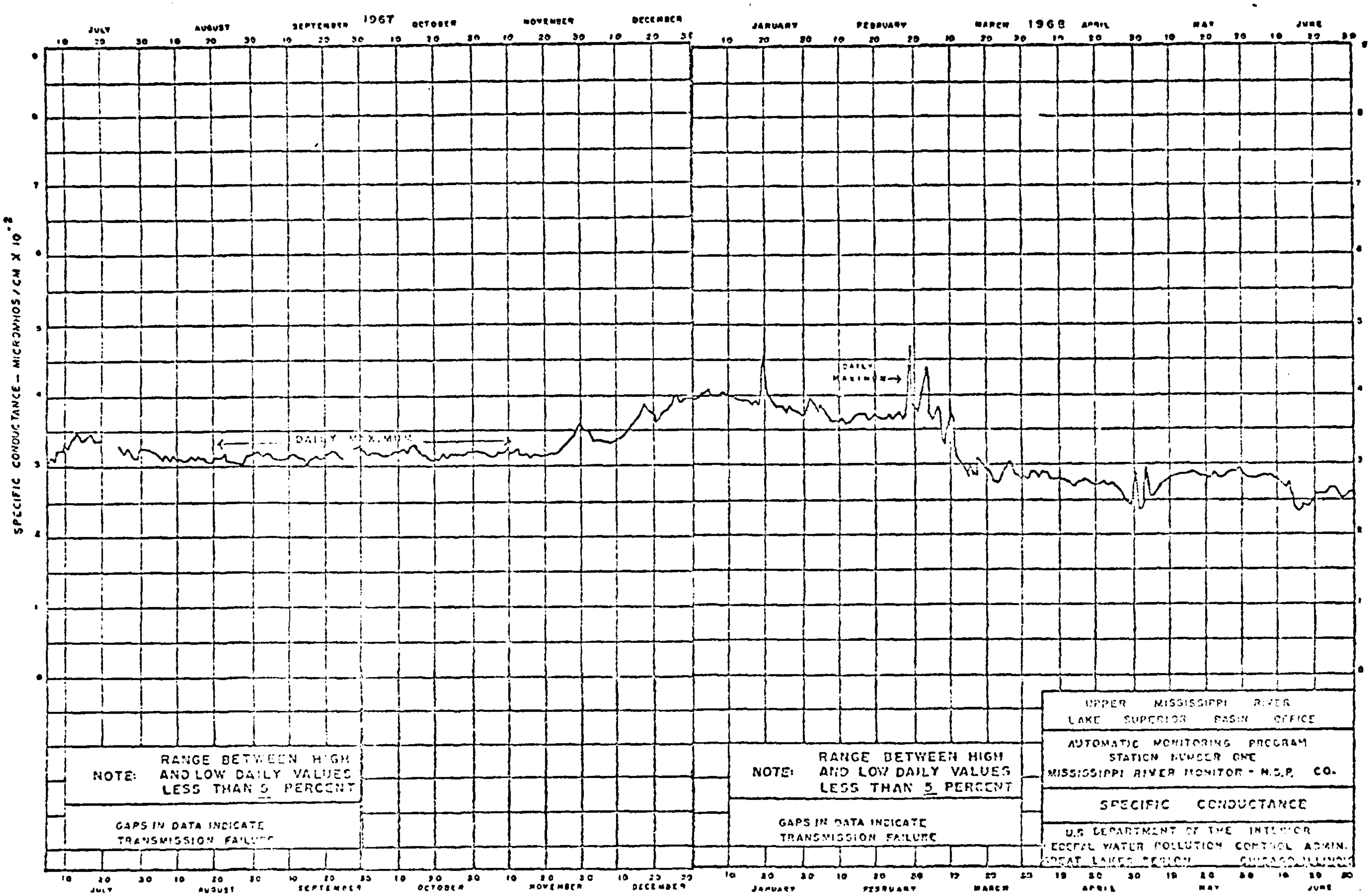

Figure 6. Seasonal Changes in Specific Conductance Measured at Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (FWPCA).

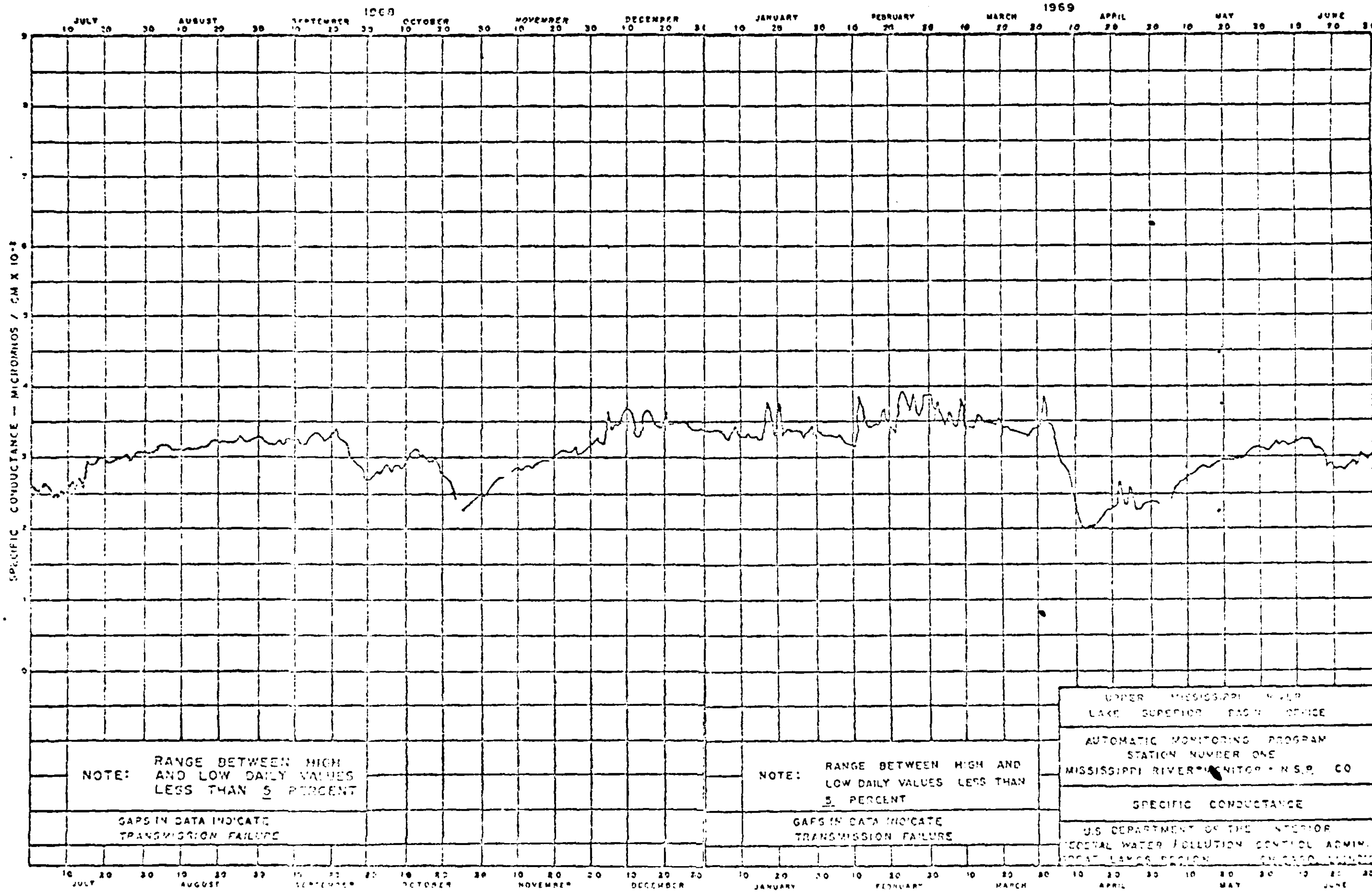

Figure 6. Seasonal Changes in Specific Conductance Measured at Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (FWPCA)(Continued).

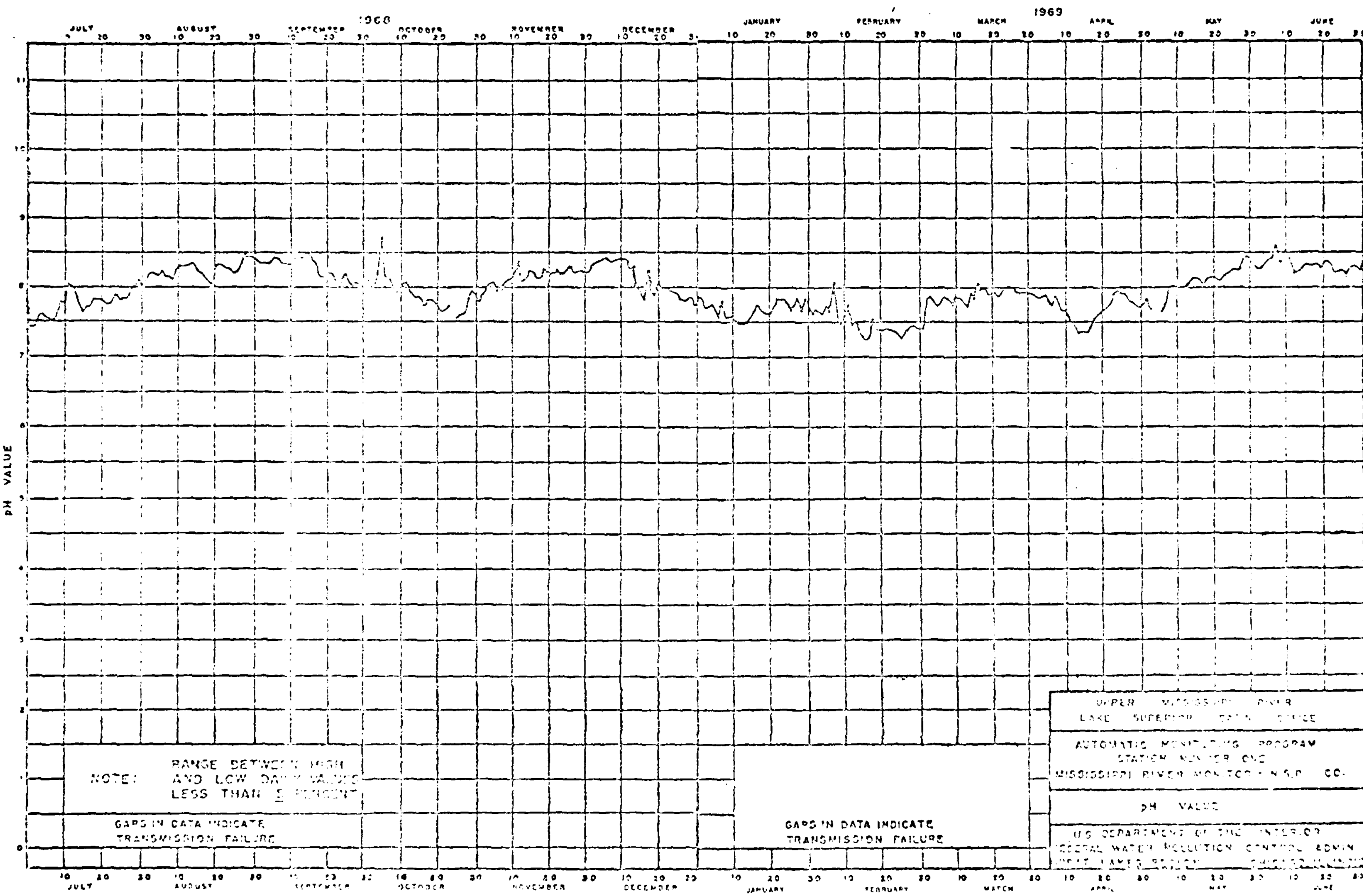

Figure 7. Seasonal Changes in pH Measured at Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (FWPCA).

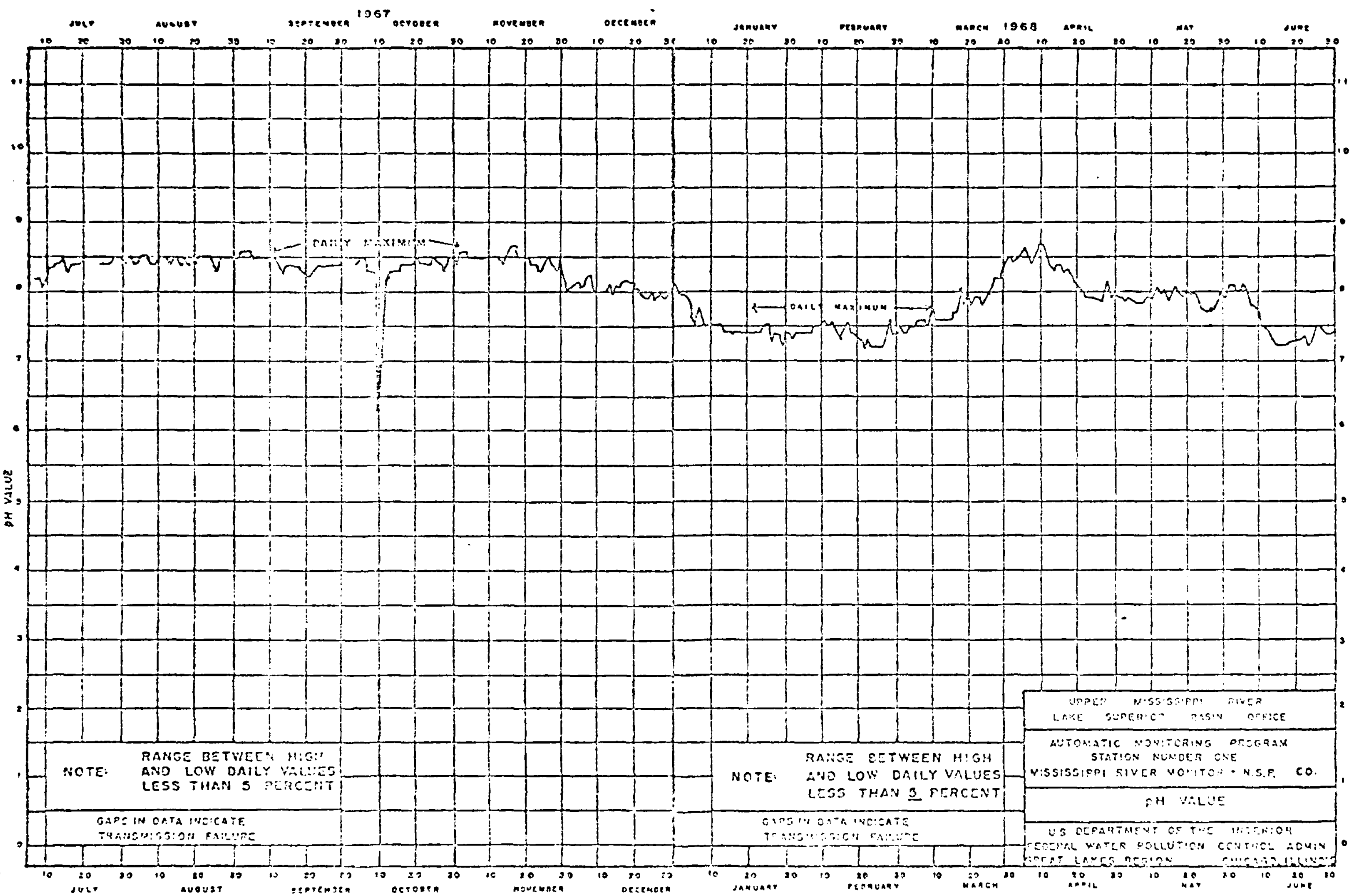

Figure 7. Seasonal Changes in pH Measured at Station 1 Mile 856.8 on the Mississippi River During a Two Year Period (FWPCA) (Continued).

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10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFORMATION

Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archaeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-size petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; eight large, well filled scapbooks of clippings on archaeological matters made by Lewis; numerous account books, vouchers, and other miscellany...

> "A single sheet of summary found among the miscellaneous papers of the survey, apparently made by Lewis, is eloquent in its significance. Tabulated by years and place of entry the mounds alone

that were actually surveyed reach a grand total of over thirteen thousand -- to be exact, 855 effigy mounds and 12,232 round mounds and linears...

"The survey is quite full for Minnesota, where work was done in all but three counties of the state, resulting in records of 7,773 mounds, besides a number of inclosures... much information was also gathered from the river counties of Nebraska, Iowa, Kansas, and Missouri. In Wisconsin the survey touched more than two-thirds of all the counties, mostly in the field of the effigy mounds in the southern half of the state, where the records supply detail for no less than 748 effigies and 2,837 other mounds. Iowa was explored most fully in the northeastern counties as far south as Dubuque, yielding data on 61 effigy mounds, 553 other mounds, and several inclosures. ...the survey yielded its richest results in Minnesota, the eastern parts of the Dakotas, northeastern Iowa, and the southern half of Wisconsin..." [Surveys were also conducted in the Dakotas, Manitoba, Missouri, Nebraska, Kansas, Illinois, Indiana, and Michigan -- in all, eighteen states.]

"The strength of the survey consists, first of all, in the dependability of Lewis as a gatherer of facts...he worked as a realist, measuring and recording what he saw with painstaking accuracy and unwearying devotion... And the fact that these surveys were made at a time when a large number of mound groups that have since disappeared, or all but disappeared, were still intact, gives the work of Lewis and Hill and incalculable worth... So far as Iowa is concerned, something like half of the antiquities of the northeastern part of the state are recoverable only from the manuscripts of the Northwestern Archaeological Survey..."

A typical description of the reporting format followed by Lewis and Hill is reproduced here:

[IN: MOUNDS IN DAKOTA, MINNESOTA AND WISCONSIN]

3. OTHER MOUNDS IN RAMSEY COUNTY, MINNESOTA

At the lower end of the Pig's Eye marsh already mentioned, there stood (April, 1868) an isolated mound, not situated on the bluffs, but below them, near their foot, at the highest part of the river bottom on the sloping ground half-way between the military road and the road-bed of the St. P. & C. R. R., then in course of construction, and distant about three hundred and fifty feet southward from the culvert on the former.

It was in a cultivated field, and had itself been plowed over for years; yet it still had a mean height of six and a half feet; its diameter was sixty-five feet. The top of it was only thirty-one feet above the highwater of the Mississippi, according to the levels taken by the railroad engineers. The location of the mound, according to U. S. surveys, was on the N 1/2 of SE 1/4 of Sec. 23, T. 28, R 22, and about one mile north of Red Rock landing. Mr. J. Ford, one of the old settlers of the neighborhood, said that a man named Odell had, some years previously, dug into it far enough to satisfy his curiosity, as the discovery of human bones clearly proved it to have been built for sepulchral purposes.

7. MOUNDS AT PRESCOTT, WISCONSIN.

At the angle formed by the confluence of the St. Croix and Mississippi Rivers, on the eastern bank of the former, is the town of Prescott, Wisconsin. On May 13, 1873, three hours' time was employed in making such reconnaissance survey as was feasible of the mounds which stretch along the bluff on the Mississippi there. The smallest of them was about twenty-five feet diameter and one foot high, and the largest fifty-six feet diameter and four feet high, as nearly as could be then ascertained.

Pictographs were common on caves along the Mississippi River bluffs. Lewis and Hill recorded their locations and frequently the pictures themselves. Although specific reference was made to them in Houston, Winona, Washington, and Ramsey counties in Minnesota and Alamakee and Clayton counties in Iowa, it would be unwise to assume that they were limited to these locations.

Captain Carver, in 1766-67 explored a cave (in present day Ramsey County) as being of "amazing depth and containing many Indian hieroglyphics appearing very ancient." The cave, called by the Dakota "Wakan-teebe", became a popular tourist attraction in the 1860's. Railroad construction was responsible for its destruction by the 1880's.

PRESENT CONSIDERATIONS

The difficulty, then, is not the absence of records of significant sites, but rather that records of thousands of sites exist. And although archaeologists

have resurveyed some of the sites, vast areas have not been checked since the original surveys. The farmer, in the course of clearing and farming his land, is chiefly responsible for the destruction of the sites, and most of the sites have by now been destroyed.

MINNESOTA

This section contains information on significant archaeological and historic sites in Minnesota.

Background

This format evolved from problems encountered in developing an inventory of sites. The listing of reasons for not doing so which follows is included because it may shed some light on future problems also.

Original plans were made to provide an inventory of Minnesota archaeological sites which lie in the study area. This idea was abandoned, however, due to the following considerations:

1. The number of sites in close proximity to the river is large and the amount of work required to review existing records (beginning in the early 1800's) exceeds the value of such an inventory in this report;

2. The records are known to be incomplete in many cases, scanty for certain areas or incorrect so that reliability of the inventory is questionable;

3. Many sites once recorded have been destroyed by the action of others (not the Corps of Engineers) but the records have never been updated. Nor has there ever been a complete systematic inventory of archaeological sites in Minnesota.

4. In many cases the location of sites given is not sufficiently accurate to determine if the site is close enough to the river bank to be threatened. In some cases, where the bluffs are close to the river bed, a vertical elevation of many feet may effectively remove a site from any threats by water, dredge spoil, or construction. The records may not show this.

5. The Minnesota State Archaeologist is understandably reluctant to publish for public consumption a list or inventory of archaeological sites because of risk of robbery, despoliation, vandalism, or unauthorized unscientific excavation. Such cases have been known in the past. However, the State Archaeologist and his staff have expressed the willingness and desire to assist individuals or government bodies in locating and identifying sites for preservation or excavation before destruction.

Impact on Prehistoric Archaeological Sites

Because the files of the State Archaeologist are located in the Twin Cities, it was possible to engage a professional archaeologist to investigate the current status of those archaeological sites in the Mississippi, Minnesota and St. Croix River areas in Minnesota. The report by consultant Jan Streiff is reproduced here in its entirety.

A Report of the Impact of the U. S. Army Corps of Engineers on Prehistoric Archaeological Sites on the Lower Mississippi, Lower St. Croix, and Lower Minnesota Rivers in Minnesota

By Jan E. Streiff, Archaeologist, Department of Anthropology, University of Minnesota, Minneapolis.

Introduction. There are approximately eighty-five (85) designated sites in the Corps of Engineers area under consideration (i.e., the Mississippi River from St. Anthony Falls to the Minnesota-Iowa border, the Minnesota River from Shakopee to Pike Island, and the St. Croix from above Stillwater to Prescott). The information on these sites has been collected since the late 1800's and all the data are filed in the Archaeology Laboratory at the University.

Although some of these sites have been revisited since being recorded, and a few have even been excavated, most have not been rechecked. Consequently there are many unknown things about most of the sites listed in this report. Ideally, a crew should have been sent out to resurvey the river

valleys in question, to determine if sites formerly recorded are still there and, if not, how they were destroyed -- particularly if by the Corps of Engineers.

Since such an on-site survey was impossible at this time, the written records will have to suffice. I have organized the known sites into the three categories shown below.

Classification of Sites.

Group I. These are sites definitely known to have been destroyed by Corps of Engineers' activities. There are nine (9) of these sites.

Group II. These are sites in the area under consideration which should not be affected by the Corps because they appear too high above the river channels. Although they may never be flooded by raised water levels, they should be kept in mind as possibly being destroyed by borrow activity, dredging, etc. There are six (6) of these sites.

Group III. This is the largest group of sites (73) within the Corps of Engineers' area. This is the group for which no definite classification can be given. There are many reasons:

a. our site location description is too vague to determine if the site is or was in danger.

b. sites which were destroyed, such as the mound groups at Dresbach, but where we cannot determine if the destruction was carried out by the Corps of Engineers dam construction or by some unrelated project.

c. sites, such as those on Pig's Eye Island, which have not been reexamined since recorded but are so located as to be assured destruction by a fluctuation in the river level or at least damaged by erosion by the river. Any dredging of the river and subsequent depositing of the debris on the nearby shore would undoubtedly cover the site.

Conclusions. Although this report is rather inadequate to determine the real impact of the Corps of Engineers on archaeological sites (there are still those 73 sites for which we have no information on Corps of Engineers' impact), it does point up the great need for future surveys along Minnesota's three greatest rivers to determine what effect the Corps of Engineers will have on prehistoric sites.

The importance of these rivers to life was no less important to the original Americans than it is to us today. And it is vital to the history of the American Indian that an attempt be made, if not to preserve, then at least to record the habitation and burial areas that are so numerous along these waterways.

The Corps of Engineers can expect that the professional archaeologists in Minnesota will do everything possible to cooperate with them to see that these ends are achieved.

February 1973

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The effect of Corps of Engineers' activities on archaeological sites in Pool 1:

<u>Group I</u>

Sites destroyed	None

<u>Group II</u>

Sites probably not affected (except by borrow)	<u>Pool 1</u> RA 5 T29 R22

<u>Group III</u>

Sites potentially destroyable	<u>Pool 1</u> RA 2 T28N R22W

RA = Ramsey County
T = Township
R = Range

Note: For the exact locations (sections, quarter sections, etc.) of the above sites, contact: Jan E. Streiff
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University of Minnesota
Minneapolis, MN 55455
(612) 373-5560

National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers Which Are Now Listed in the National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The <u>Register</u> is an official statement of properties which merit preservation. Several sites adjacent to the Mississippi, Minnesota and St. Croix Rivers in Minnesota are listed in the latest (1972) edition of the <u>National Register of Historic Places</u>. Generally, these sites have not been destroyed or damaged extensively by previous Corps of Engineers' activity, but must be considered as possibly vulnerable in the future. None of these sites is located adjacent to Pool 1.

Glossary

acre-foot - the quantity of water required to cover an acre to a depth of 1 foot. It is equivalent to 43,560 cubic feet.

alluvial material - sediment, usually sand or silt, deposited on land by flowing water.

aerobic - an environment in which free oxygen is present.

anaerobic - an environment in which free oxygen is lacking.

aquifer - a water-bearing layer of porous rock, sand, or gravel.

backwaters - a term often divided now into sloughs and lakes and ponds adjoining a river.

benthic - pertaining to the bottom of a body of water.

benthic invertebrates - animals lacking a spinal column living in the benthic zone.

BSFW - Bureau of Sport Fisheries and Wildlife (U. S. Department of the Interior).

channel - a natural or artificial watercourse with definite bed and banks which confine and conduct flowing water.

cfs - cubic feet per second, used as a measure of rate of water flow in a river.

chute - sloping channel or passage through which water may pass.

closing dam - low dam extending across a side channel. These were constructed to divert water from side channels to the main channel during low water periods to maintain water sufficient for navigation.

coulee - steep-sided tributary valleys, commonly used in Wisconsin.

deciduous forest - forest dominated by broad-leaved trees which lose their leaves each autumn.

discharge (rate of flow) - the quantity of water passing a point in a stream channel per unit of time, normally measured in cubic feet per second (cfs).

drainage area - the land area drained by a stream above a specified location on the stream. Measured in a horizontal plane, it is so enclosed by higher land (a divide) that direct surface runoff from precipitation normally drains by gravity into the stream above that point.

drawdown - a process of lowering the water level of an impoundment.

Driftless Area - the portion of southwestern Wisconsin, southeastern Minnesota, northeastern Iowa and northwestern Illinois which was virtually untouched by the last advance of the Pleistocene glaciers (i.e., Wisconsin Glacier). It is thought by many that it was never glaciated.

flood - a temporary rise in streamflow and water level (stage) that results in significant adverse effects in the vicinity under study.

flood peak - the highest value of water level or streamflow attained by a flood.

floodplain - the relatively flat lowland adjoining a watercourse or other body of water subject to overflow therefrom.

FTU - Formazine Turbidity Units - arbitrarily defined units used as standard for measuring water turbidity, currently recommended by APHA, et al., 1971.

gaging station - a site on a stream, canal, lake or reservoir where systematic observations of water-surface elevation or streamflow (discharge) are obtained.

humus - the surface layer of soil combining partially decomposed organic matter and mineral particles.

JTU - Jackson Turbidity Unit - arbitrarily defined units used as a standard for measuring water turbidity.

lake and pond - open areas with little or no current. They are formed behind dams, or on mature floodplains as a result of first scour, then abandonment, by the lowered river.

littoral - the shore zone of a body of water.

macroinvertebrates - collectively, all invertebrate organisms visible with the unaided eye.

main channel - the portion of the river used for navigation by large commercial craft. A minimum depth of 9 feet and a minimum width of 200 - 400 feet were established by the lock and dam system and are maintained by periodic dredging.

main channel border - the water zone between the main channel boundary and the main river bank, islands, or now submerged channel boundaries. Wing dams are located in this zone.

mesic - a type of vegetation which develops under moderate moisture conditions.

moraine - an accumulation of earth and stones carried and finally deposited by a glacier.

MPN/l - most probable number per liter - an estimate of bacterial abundance (See Methods, Appendix AI).

MRRC - Mississippi River Research Consortium

MRRPC - Mississippi River Regional Planning Commission

mussels - clams, bivalves of the Phylum Mollusca.

outwash - glacial till reworked and sorted into sand and gravel, etc., by meltwater.

pedalfer soils - well-leached soils; soils that lack a more or less hardened layer of accumulated carbonates.

pedocal soils - soils that develop under approximately equal precipitation and evaporation conditions; soils that contain a definite more or less hardened layer of accumulated carbonates.

physiography - a branch of science that deals with the physical features of the earth.

phytoplankton - collectively, all those plants suspended in and on the surface of the water, usually microscopic.

piezometric surface - surface to which water of a given water-bearing rock unit will rise under its own pressure balance; an artesian water table.

plankton - free-floating plants and animals drifting in the water, usually microscopic.

podzolic - light-colored acid soil developing under coniferous forests, in cool, humid regions; result of leaching and removal of soluble minerals from the top layer into the deep layers.

riprap - rock fortifications on banks or shores which protect them from erosion by dissipating the energy of waves and wakes.

River Mile - miles above the entrance of the Ohio River at Cairo, Illinois measured on the river.

river stage - the elevation of a particular river surface.

roller gates - movable gates of dam, horizontal cylinders on inclined tracks which can be adjusted to affect water flow and its level.

rookery - the nests and breeding place of a colony of birds; the colony of birds.

runoff in inches (in.) - the depth to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on it.

savanna - grassland with trees spaced so far apart that their crowns are separate and the grass receives direct sunlight.

side channel - departures from the main channel or main channel border. At normal river stage, a current occurs in these channels.

slough - body of water through which there is no current at normal river stage. Muck bottoms and an abundance of submergent and emergent vegetation are characteristic. The slough category lies somewhere between the side channel and lake and pond categories.

spoil - waste material removed in making an excavation.

streamflow, discharge - the volume of water passing a point, per unit time, measured in cfs or in cubic meters per second.

tailwaters - water areas immediately below the dams. They are affected by the movement of water through the gates and locks, and they change in size in response to changing water levels.

tainter gate - movable gate of a dam which is a horizontal cylinder segment mounted on a steel framework attached to a horizontal downstream rod so it may be adjusted up and down to affect water flow and its level.

thermocline - a layer in an incompletely-mixed body of water where the temperature during the summer drops rapidly (more than 1°C. per meter) as the thermometer is lowered.

till - unsorted rock, sand and gravel deposited by the melting of glacier ice.

UMRCBS - Upper Mississippi River Comprehensive Basin Study.

UMRCC - Upper Mississippi River Conservation Committee.

watershed - drainage basin or drainage area.

weathering - the geologic process of decomposing rocks by the action of the forces of weather.

wing dams - low structures extending radially from shore into the river for varying distances to constrict low water flows. They were constructed of rocks and brush mattresses to establish a deeper main channel.

zooplanktonic - pertaining to the animal life of plankton.

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8